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NOISE & PLANNING

A MONOGRAPH ON TRAFFIC NOISE IMPACT & CONTROL

1975 – 1979

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Ontario

Ministry
of the
Environment

The Honourable
Harry C. Parrott, D.D.S.,
Minister

Graham W. S. Scott,
Deputy Minister

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NOISE AND PLANNING

A MONOGRAPH ON TRAFFIC NOISE
IMPACT AND CONTROL

1975 - 1979

EDITED BY: J. Manuel P.Eng MEIC

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FOREWORD

Although the Noise Pollution Control Section of the Pollution Control Branch of the Ontario Ministry of the Environment has to a large extent, over the past five years, formalized the noise assessment and project approval process by publishing noise guidelines, criteria and reporting procedures, the public-at-large and in some respects the construction industry seemingly continue to be unaware of the significant advances made in planning during the last decade with respect to noise control.

The fact that the government of Ontario and Canada Mortgage and Housing Corporation, an agency of the federal government, have both published noise guidelines, land-use criteria and training manuals reflects their concern over the pervasive problems of noise and particularly transportation noise. Indeed,public pressure in Ontario has already influenced the roads authority to embark on a costly noise barrier retrofit program. To date, several miles of noise barriers have been built or are in construction and more than one hundred additional feasible freeway sites have been identified for future construction of barriers.

In order to avoid unnecessary expense and public reaction in future years, a provincial noise level objective for all new construction near freeways has been established. This monograph, although repetitious at times, is intended to present the stated policy objective in all its component parts and facets as seen through the eyes of many professionals intimately involved in regulation, assessment, planning and design and in highway and housing construction.

John Manuel
Editor

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SOUND, SITE DESIGN, AND STRUCTURES: ASPECTS OF LAND-USE PLANNING

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This paper appears in "Noise in the Human Environment, Volume 1," published by the Environment Council of Alberta.

Land-use planning may prevent noise problems and complaints. This is done primarily by separating noise sources from noise-sensitive land uses, especially residential development. Where adequate separation is impossible, other noise-control measures are required. In this paper, the general principles of land-use planning in relation to noise considerations are discussed with particular reference to practices in Alberta and Ontario. The specific techniques discussed include: the set-back of residences from noise sources; the arrangement of buildings on a site; the use of acoustical barriers; the insulation of buildings; and the placement of rooms, windows, and exterior spaces. The material is presented at a level suitable for a wide audience.

1. INTRODUCTION

The basic philosophy of land-use planning with respect to noise is first to avoid noise problems and complaints either by placing new residential or other land uses sensitive to noise away from existing noise sources or by placing new noise sources away from existing residential developments. This basic statement of aims has to be extended in cases where the planning process is ahead of information about noise. Second, when incompatible land uses are planned, control measures should be investigated to lower noise levels in sensitive areas. This latter process needs careful attention as often the alternatives available to the developer are limited.

Many sources of noise require consideration in the land-use planning process, but the major source is from transportation. Highway traffic noise is usually the dominant transportation-noise source, with railways a close second. The network of highways and railway tracks spreads across Canada and much new development occurs close to these transportation corridors.

Noise from roads and railways is restricted to ground level and can be controlled more easily than that emitted from aircraft. Very little can be done to alleviate aircraft noise other than to have sufficient distance between the airports and their associated flight paths and the noise-sensitive areas. This restriction places aircraft noise into a category of its own within the land-use planning framework. Industrial noise is not as widespread as the other sources, but often has a variety of characteristics making it particularly unpleasant and difficult to control. Within these limitations, this paper focuses on the basic philosophy of land-use planning with respect to noise. The planning and decision-making procedures that are the outgrowth of this philosophy are in the process of being developed so they will be more effective.

2. SOUND-LEVEL LIMITS

Perhaps the most difficult aspect of dealing with noise in the land-use planning process is setting noise limits because this decision has many attendant implications. These limits are set basically as a compromise between two opposing influences, namely, minimizing annoyance from noise, and minimizing the economic cost of measures to control noise. If sound-level limits are set too low, large sums could be spent unnecessarily on buffer lands and other methods of attenuating noise. If levels are set too high, annoyance and complaints will result despite any expenditure on noise-control measures.[1,2]

It is pertinent to ask whether sound-level limits should be specified and used at all because very often factors other than noise have a greater influence on land-use planning decisions. Economic, physical, or topographical constraints, demand for certain types of development, and so on all go into the planning process along with noise considerations. Without fixed sound-level limits, greater flexibility in planning may mean that other factors would be more easily included in the overall process.

One drawback to such a procedure, however, could be described as the "user expectation" of those people moving into a new residential subdivision. Evidence indicates they "expect" a certain amount of peace and quiet at their newly purchased property. It is of little comfort to them that noise-control measures were not instituted or required for economic or other practical reasons. If the collective demand of a community is for quieter surroundings, recital of the factors which lead to the situation has only a marginal effect on the complaints. If noise-control measures are eventually introduced, they usually cost much more than they would have in the first place.

A second problem related to noise control in land-use planning when noise limits are not established, is that no objective limit is available. Such a situation could result in too little or too much noise reduction producing either annoyance and complaints, or overexpenditure on noise abatement measures.

This discussion indicates that a system must be devised which provides both an objective set of sound-level limits and also a degree of flexibility in their application. This can be achieved by setting a sound range rather than a single sound limit. The specification and use of a range, however, needs very careful definition as the upper limit, in many cases, could be the only limit used. Using only the upper range could result in noise-control measures that are under-designed in some circumstances; annoyance and complaints could well follow. The lower sound-level limit should represent the level at which annoyance would be minimized and should be used as a design objective for noise-control measures wherever possible. The upper sound-level limit of the range would represent the level at which annoyance would be certain and complaints possible. That upper limit should be used as the level above which, *after* noise-control measures have been instituted, new residential development should not be allowed. Thus, the use of the upper limit would ensure that developments were not permitted in surroundings noisy enough to cause a serious impact on the local population.

For developments which lie within the sound-level range, the flexibility available to the developer with respect to possible noise-control measures should be carefully investigated. At an advanced stage in the planning process, topographical constraints or even economic factors could well limit the feasible noise-control measures which the developer might adopt, thus making it difficult or even impossible to reach the lower sound-level limit of the range. In such a case, the lowest sound level possible within the range should be the objective.

In some cases, this approach does allow noise levels above the lower limit and, hence, there will be some annoyance. Evidence suggests this approach would cause few complaints. It seems reasonable that where the lower limit is not achieved prospective purchasers of affected properties should be notified of the residual noise problem. The wording of this notification or warning clause should also reflect the magnitude of the residual noise problem or the excess above the lower sound-level limit. The difficulties of successfully instituting such warning clauses will be covered later in this paper when planning procedures are discussed.

Following from the discussion above, then, sound-level limits are required to set the lower end of the range, are used to determine suitability for residential development, and should be objective or design value for noise-control measures.[3] [4] The Noise Pollution Control Section of the Ontario Ministry of the Environment, has been actively integrating noise considerations into land-use planning for almost four years. Initially, the section derived a set of noise-level limits for new residential development from a publication of the United States Department of Housing and Urban Development.[5] Through a process of refinement,[6] these limits emerged in the form given in Tables 1, 2, and 3 which are extracted from the Model Municipal Noise Control By-law of the Ontario Ministry of the Environment.[7] This set of sound level limits is not final,[6] although the broad philosophy behind them is thought to be reasonably correct.

Two points concerning these limits need further discussion. The first concerns the night-time outdoor limit while the second relates to the use of L_{50} with L_{eq}. The night-time outdoor limit occurs because of a fixed relationship between the corresponding outdoor and indoor limits. Typically, a 10 dB attenuation between outdoor and indoor noise levels with open windows is assumed, although values of 13 to 15 dB are more likely with smaller-sized windows and absorptive interiors in new construction. Satisfying the night-time outdoor noise-level limit will automatically ensure that the corresponding indoor limit is met. If the night-time indoor limit were met, possibly by using suitable glazing and ventilation, the night-time limit could be waived. This latter statement is of particular importance in areas where heavy night-time traffic exists or is anticipated.

The use of an L_{50} noise-level limit in addition to L_{eq} creates some controversy in Ontario. The philosophy behind use of this additional limit as stated in Gidamy[6] is that L_{eq} does not adequately represent nearly continuous or steady sound. For steady sound, the use of the L_{50} limit requires the value of L_{eq} to be 3 dB lower than that shown in Tables 2 and 3, and although this has been criticized as being too small to be worthwhile, Gidamy[6] points out this is the smallest acceptable restriction in the assessment of steady noise. Continuing research into the adequacy of noise descriptors and use of any single descriptor (including L_{eq}) should be avoided. For example, several European proposals consider the effects of peak noise levels in assessing new residential land uses. A second set of sound level limits presently in use in Canada are those contained in *Road and Rail Noise: Effects on Housing,* a CMHC document produced in co-operation with the Division of Building Research, National Research Council of Canada.[8] These limits are reproduced in Table 4.

Differences between these limits and those of the Ontario Ministry of the Environment[7] are slight but worth comment. First, day and night sound levels are not used since twenty-four hour L_{eq} values are specified. Although Table 4 has the advantage of simplicity, it means that a day-time dominated L_{eq} is used to design noise-control measures for bedrooms. Second, the CMHC indoor sound-level limits for bedrooms and living rooms are 5 dB lower than those used by Ontario. The levels presented in Table 4 provide a more suitable indoor noise environment than those of Table 1, but may require additional glazing and ventilation. The CMHC sound levels are used for deciding suitability for financing under The National Housing Act rather than for subdivision approval to which the Ontario levels apply. As such, that the CMHC levels should be set slightly

Table 1

Indoor Sound Level Limits [3]

Type of Space	Equivalent Sound Level (L_{eq}) dBA
Bedrooms, sleeping quarters, hospitals, etc. (Time period 2300-0700 hours)	40
Living rooms, hotels, motels, etc. (Time period 0700-2300 hours)	45
Individual or semi-private offices, small conference rooms, reading rooms, classrooms, etc. (Time period 0700-2300 hours)	45
General offices, reception areas, retail shops and stores, etc. (Time period 0700-2300 hours)	50

Table 2

Sound Level Limits for Outdoor Recreational Areas

(0700-2300 hours)[3]

Sound Descriptor for the Entire Period	Sound Level Limit dBA
L_{50}	52
L_{eq}	55

Table 3

Sound Level Limits for Outdoor Areas

(2300-0700 hours)[3]

Sound Descriptor for the Entire Period	Sound Level Limit dBA
L_{50}	47
L_{eq}	50

lower seems reasonable. Interestingly, the CMHC document requires only L_{eq} to describe the noise environment; no other descriptor is specified.

Table 4

Maximum Acceptable Levels of Road and Rail Traffic Noise in Dwellings and Outdoor Recreation Areas

	24 Hour L_{eq}
Bedrooms	35 dBA
Living, dining, recreation rooms	40 dBA
Kitchens, bathrooms, hallways, utility rooms	45 dBA
Outdoor recreation areas	55 dBA

The noise level limits indicated so far refer primarily to urban and suburban development and are meant to meet the "user expectation" of noise in such areas. In rural areas, however, such noise levels may well be thought too high and may not give the peace and quiet people seek when they buy property in rural surroundings. Little documentation relates to noise level limits for rural areas, although ISO R 1996 does suggest levels relatively lower than their urban counterparts. Forthcoming revisions of R 1996 may consolidate this point of view.[9] The Ontario Ministry of the Environment has investigated this topic and material relating to it has been published.[7] The Ministry has also decided to declare the equivalent noise level 40 dB, A-weighted, to be the lowest level of concern in environmental planning and in enforcement.

3. NOISE AND THE PLANNING PROCESS

The planning process must necessarily cover many and often contradictory concerns such as air pollution, water pollution, sewage services, housing demand, marketability, economics, and politics. The final decisions rest with the planning experts who necessarily take a broad view. The planning process is progressive; usually it is a gradual process of refinement and, hopefully, improvement. The acoustical engineer should take his place alongside others in this refining process. He should ensure that his concerns are presented and considered within the evolving planning process. He should provide his own procedures and have the resources to handle the part of the planning process for which he is responsible.

Land-use planning in Canada is basically a local matter and as such is handled by the provincial level of government, with delegation to the municipal level in some cases. Thus, some ten provincial planning processes are in various stages of development and use, and are perhaps moving in different directions. The words "the planning process" in the heading of this section may seem rather inappropriate. To narrow the field somewhat, provincial planning processes from Alberta and Ontario only will be considered. In Ontario, noise has been considered part of the planning process for several years. However, it should not be thought of as the ultimate or even as a model. In fact, The Planning Act is under review in Ontario.

3.1 Regional Planning in Alberta and Ontario

Planning responsibilities in Alberta (as in Ontario) are shared between the provincial government and the municipalities. The enabling legislation for land-use planning in Alberta is in The Planning Act (RSA 70 c. 276), as amended and The Subdivision and Transfer Regulations 215/67 as amended.* Under the Act, the responsibility for land-use planning is vested in the Minister of Municipal Affairs who recommends the appointment of a Provincial Planning Board which is responsible for enforcing the Act and formulating and administering regulations assigned to it. The Planning Board also advises on the establishment and administration of Regional Planning Commissions and the co-ordination of their activities. In addition, the Board hears appeals against decisions of a Director or other matters coming within its jurisdiction.

Regional Planning Commissions are established to cover specific planning regions in Alberta. Each municipality situated within a region may be represented by one member of the Municipal Council at the annual general meeting of the Regional Planning Commission and at any other regular meeting of the commission at which there will be consideration of an item of business of a planning nature affecting that municipality. A Regional Planning Commission studies the resources and development of the Regional Planning Area with a view to preparing a regional plan. When asked, the Commission will also advise and assist municipal councils in the region to plan orderly and economical development by recommending or preparing a general plan, development schemes, development control by-laws, and zoning by-laws.

To supplement the planning process, a municipal council may, through a by-law, establish a municipal planning commission, independent of council, to act as a subdivision approving authority. It may also administer a development control by-law and a zoning by-law.

In Ontario, regional municipalities have been delegated planning powers and have undertaken broad planning. They must produce a Regional Official Plan within a certain time. Municipalities themselves can also produce official plans. These plans are statements of intent that describe how lands within the regional municipal or municipal boundaries are to be used. When the Official Plan is eventually approved by the Minister of Housing, it is binding in that all future zoning by-laws, municipal undertakings, and private sector developments must conform to the official plan.

Considerable time and effort goes into the preparation of a plan before it reaches the stage where it can be submitted to the Minister for approval. Some of the things that may have to be done are: land classification and inventory, mapping, population projections, analysis of transporation and servicing requirements. Municipal departments, citizen and industrial groups, provincial and possibly federal agencies, and conservation authorities must be consulted. This work may be done by municipal planning staff, a consultant engaged for the express purpose, or by a combination of the two. The Noise Pollution Control Section of the Pollution Control Planning Branch of the Ontario Ministry of the Environment is often called at this stage in the formulation of the official plan. The form of assistance varies but can be in terms of general policy, advice on a particular approach for single noise sources or, in some cases, advice on sound level limits to be incorporated into the official plan. When it is eventually written in its final form, the plan must be adopted by council, as a Proposed Official Plan, before it is submitted to the Minister of Housing for approval.

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*Since this paper was written, The Planning Act (RSA 70, c. 276) has been repealed and replaced with The Planning Act, 1977 (S.A. 1977, c. 89) which was assented to November 10, 1977). As well, The Subdivision and Transfer Regulation (Alberta Regulation 215/67) under the old Act has been repealed and replaced with The Subdivision Regulation (Alberta Regulation 132/78) under the new Act. The new legislation includes several revisions in the names and responsibilities of organizations referred to in the paper, as well as changes in the regional planning process and in the subdivision approval process. For an updated account of the new provisions, procedures and responsibilities, it will be necessary to consult the new Act and Regulation.

Sufficient copies are submitted so that the proposed plan can be referred to other ministries and agencies for comments. Conflicts with the policies, programs, and objectives of these other ministries and agencies can, thus, be identified. This review also provides an opportunity for comment on matters of concern, such as availability of water and sewage services, hazard lands, drainage, access to highways, air quality, noise, management of solid waste, agricultural land, housing needs, and school space.

This referral process allows noise concerns to be voiced at an early stage in the planning process along with other concerns of importance. One difference here from the Alberta system is that the various comments are not discussed by a board, but are returned to the Ministry of Housing where they are considered by planning staff.

Comments on the Proposed Official Plan made by the Ontario Ministry of the Environment and the other ministries and agencies are advisory only. The decision to approve or to modify the official plan is made by the Minister of Housing. Modifications may be required or imposed by the Minister as a result of the advice received and on the recommendations of his staff. The Proposed Official Plan, in part or in whole, may be referred to the Ontario Municipal Board (OMB), by the Minister or municipality for arbitration. Staff of the Noise Pollution Control Section can be subpoenaed to appear as expert witnesses before the OMB under provisions of the Municipal Board Act.

The Ontario government recently announced that because planning concerns are widely based, the responsibilities of the individual ministries must be dealt with on a co-ordinated basis. Consequently, an Interministerial Land-Use Committee has been formed. This committee, which is not intended to perform the actual task of land-use planning, but rather is to facilitate land-use decision making in the province, seems broadly similar to the Alberta Planning Board and will provide a forum for broad discussion of often contradictory planning concerns at cabinet level.

3.2 Subdivision Approval in Alberta and Ontario

Under the Alberta legislation, the subdivision of all land is subject to certain provisions: the land must be suitable for the purpose for which each subdivision is intended and is expected to be used for that purpose within a reasonable time after that plan is registered. The planned subdivision must conform to any existing general plan, regional plan, or development and zoning by-law affecting the land or adjacent land. The proponent must provide those public works, facilities, and reserves required of them under The Subdivision and Transfer Regulations.

The Subdivision and Transfer Regulations describe the procedure to be followed by applicants for approval of proposed subdivision and by the approving authorities. The regulations also provide the rules for laying out subdivisions and, together with some related detailed requirements, locations for subdivisions intended for certain types of development. When an application has been approved, the proponent must submit, within twelve months after the date of approval, a plan of subdivision to the authority. If the approving authority is satisfied that the plan conforms to the original application, the authority endorses it with a Certificate of Approval. If the plan is not submitted within the time allowed by the approving authority, the original approval becomes void.

A plan of subdivision that has been endorsed by an authority other than the Provincial Planning Board is forwarded by that authority to the Board's Director who, if satisfied, endorses the plan with a Certificate of Approval. The endorsement may specify a time within which his endorsement is effective. This time requires the proponent to take all necessary steps required of him so that the Registrar of Land Titles may register the plan during the period specified. If the Director refuses to endorse an approved plan, the proponent has recourse to the Planning Board and to the courts.

Under The Subdivision and Transfer Regulations, the subdivision approving authority may, within seven days after receipt of an application, require from the proponent additional information in writing. Further, when appropriate, the approving authority may request that such information be supported by a report by a qualified consultant with respect to the adjacent existing land use and land surface characteristics within one-half mile of the land to be subdivided. It may also ask for any other necessary related information. Land may be subdivided only if it is suitable for, or can be economically adapted to, the purpose for which the subdivision is intended, having regard to the needs of good planning.

If the Alberta government chooses to recognize noise as a concern in the planning process, it can be fitted into the framework described. The approving authority (under the aegis of the Provincial Planning Director) will need access to expertise necessary to draw up objective sound level limits for residential (also educational, institutional, and office) developments, so that a basis for assessment would exist. Inevitably, these limits cannot be met in some cases. Consequently, the authority will require the ability to check the effectiveness of noise-control measures proposed by the developer or his consultants.

It could well be that a convenient arrangement would be that the day-to-day approval of subdivisions with respect to noise should be handled by regional planning commissions. In this case, perhaps overall planning policy with respect to noise should remain with the provincial level in Alberta.

In Ontario, draft plans of a subdivision are submitted by the applicants to the Ministry of Housing or the Regional Municipality as appropriate. As a matter of prudence, most prospective developers consult with the local, or area municipality before formally submitting their applications. As has been described, the draft plan is circulated for evaluation. In the case of noise, close contact between the developer and the Noise Pollution Control Section is recommended in order to discuss and agree upon the noise-control measures required to reduce noise to acceptable levels on the site.

The concerns of the Ministry of Housing and the other ministries and agencies can be incorporated into the Conditions of Draft Approval for a proposed development. In the case of an adverse comment involving noise, often a Condition of Draft Approval may state that the developer undertakes to incorporate acceptable noise-control measures on the site. The place for making such an undertaking is in the Subdivider's Agreement, entered into between the developer and the municipality, where noise control measures can be specified in detail.

Under the Ontario system, although no specific legal requirement exists to persuade developers to institute noise-control measures as such, the noise-control requirements have been included in The Planning Act and appear in legal documents such as The Subdividers Agreement. This formalization resulted from four years of local experience. No doubt similar arrangements could be made within the Alberta planning process, if noise were accepted as a necessary concern.

4. PROCEDURES FOR DEALING WITH NOISE IN THE PLANNING PROCESS

Several years of experience in including noise considerations in the planning process in Ontario has shown that the number of projects investigated has increased substantially. The Noise Pollution Control Section of the Ministry of the Environment has handled over 2,000 land-use files in less than four years and these represent only the most serious noise-impacted projects. Such a volume of work to a large extent, dictates the procedures used for processing the jobs. Approval procedures must be streamlined, bureaucracy and inefficiency minimized, and suitable staff hired and used to the full.

4.1 Submission Guidelines

In Ontario much time can be spent gathering enough data to evaluate the impact of noise on a new subdivision. This data-gathering exercise can be considerably reduced by asking the proponents themselves to perform that task. To prevent delays, approval submission guidelines[10] were prepared to inform developers, architects, and contractors what data would be necessary. Typically, data on trains or traffic, descriptions of industrial sources of noise, distances, and topographical information would be required.

4.2 Initial Comments

In the early stages of investigating noise aspects of a new land-use proposal, noise levels for the site must be established and compared with the objective (lower) sound-level limit. This comparison will indicate whether noise will be a problem. If it will be, the extent of the problem will be apparent. At such an early stage, there would probably be no need to investigate noise-control measures.

These Initial Comments need to be handled promptly and efficiently so that projects with no noise problem are not held up unduly and to allow solutions to indicated problem areas to be investigated at the earliest opportunity. Twenty-four-hour monitoring of noise levels is a time-consuming operation which could well require extensive travelling, and should only be used where no accurate techniques to predict noise are available. For railway and highway noise, such predictive techniques are available and, given reliable input data, should be acceptable.[8,11,12] Wherever possible, agencies should have methods programmed on computers or programmable calculators to make it possible to perform rapid and accurate sound level predictions. Printed records of all input data and predicted sound levels should be available for record purposes.

To further streamline the Initial Comments procedure, standard letters should be written to cover the various noise problems encountered. As these letters may often be sent to non-technical planning staff, some subjective assessment of the magnitude of the noise problem should be included (Figure 1).

The Initial Comment procedures are facilitated if they can be handled, at least in part, by non-technical staff. To this end, courses on land-use planning with respect to noise could be offered[13] for staff of approval agencies, regional governments, municipal planning teams, developers, and their consultants. The use of predictive models should be an essential portion of such a training course. Other documents could be prepared[14 15] to allow relatively simple estimation of noise levels and, as will be discussed below, the measures required to remove any noise problems.

4.3 Investigation and Approval of Noise-Control Measures

It is doubtful that approval agencies could fully design the noise-control measures for all incoming land-use jobs having noise problems even if they wanted to. This task must be left to the developer and his consultants who should be considerably assisted by various documents.[14,15]

Discussions may well have to be arranged between the developer (possibly accompanied by his consultants) and the municipality with whom the developer may finally have to enter into a written agreement to institute the agreed noise-control measures. In some cases, agency staff trained in acoustics will find that other concerns such as ease of access, fire access, aesthetics, and economics, will have to be considered and may well decrease the effectiveness of the noise control concepts suggested. Reasonable compromises will necessarily have to be found in such circumstances. The approving agency staff must realize that people will have to live in the homes under consideration and yet must ensure that noise-control measures are not unnecessarily eroded by the developer or his architect.

Figure 1

Subjective Evaluation of Noise

Excess Above Recommended Sound Level Limits dBA	Change in Subjective Loudness Above Recommended Sound Level Limits	Magnitude of the Noise Problem	Noise Control Measures (or action to be taken)
No Excess	----	No expected noise problem	None (No warning clause)
1 to 5 inclusive	Noticeably louder	Slight noise problem	Optional (if no physical measures are taken then prospective purchasers or tenants should be made aware by a clause in the deed or rental agreement (Warning clause required)
6 to 10 inclusive	Almost twice as loud	Definite noise problem	Necessary (Warning clause required)
11 and over	Three or more times louder	Serious noise problem	Essential (Warning clause required)

5. NOISE-CONTROL MEASURES

This section discusses the noise-control measures available to the developer and provides examples or suggestions on how specific measures can be instituted on a given site in terms of site design, acoustical barriers, architectural design, and construction techniques. The term "noise-control measures" refers to any action that could be taken to reduce noise levels on a site to acceptable levels and thus achieve compatibility for the specific land use or activity. A table of noise control measures is shown in Figure 2.

5.1 Site Planning as a Noise-Control Measure

Site planning is a relatively simple and effective technique for reducing the impact of noise on a new development. In general, site planning involves arranging buildings, facilities, and recreational areas by placing them away from the noise source so as to provide maximum protection for areas sensitive to noise. Uses insensitive to noise should be placed close to the source. The usefulness of site planning will be affected by such factors as the inherent flexibility available, existing or proposed designation in regional or official plans or zoning by-laws, the relative size of proposed buildings and the site itself, and the form or density of development intended for the land. Site planning techniques that may be used are shown in Figure 2.

5.1.1 Distance Setback

Increasing the distance between residential developments or any land-use sensitive to noise and the source of noise can be a useful means of reducing noise levels. Distance setback is most useful where areas sensitive to noise are already close to the source of the noise. Distance is, however, one of the very few noise-control measures suitable for obtaining acceptable noise levels on the balconies of apartment buildings which overlook a noise source since the use of a barrier is prohibited by the very height of the balconies themselves. The balconies could, of course, be removed or placed solely on the other side of the building, a technique discussed later.

5.1.2 Uses Insensitive to Noise

Land vacated as a result of distance setback need not be left unused. This land can be used for any purpose, practically so long as that use itself does not produce excessive noise levels. Examples of uses insensitive to noise are parking, which is necessary in residential developments, or, uses unconnected to residences (such as light industry or commercial developments). Of course, if buildings constitute a large part of the noise-insensitive usage, a further decrease in sound levels could be achieved, which would allow a reduction in the original distance setback and release more land for residential purposes.

5.1.3 Orientation of Buildings and Outdoor Recreation Areas

An acceptable noise environment can often be achieved in outdoor recreation areas on a subdivision by careful orientation of these areas and the buildings on the site. Once outdoor noise levels have been reduced in this way, indoor noise levels can be controlled using further techniques outlined later in this section.

Figure 2

Summary of Noise Control Measures Applicable to Design of New Housing

Noise Control Measures

- Site Planning
  - Distance setbacks
  - Insertion of noise insensitive buffer zone
  - Orientation of outdoor recreational areas
- Acoustical Barriers
  - Favourable topographical features as barriers
  - Earth berms
  - Barrier walls and fences
  - Intervening structures as barriers
- Architectural Design
  - Orientation of balconies and terraces
  - Room and corridor arrangement
  - Orientation of windows
  - Blank Walls
- Construction Techniques
  - Acoustical treatment of walls, windows, doors and roofs
  - Air conditioning and ventilation

For design purposes, vegetation, plantings and trees should not be considered as being acoustical barriers.

An outdoor recreation area is considered to be any area where *quiet* is important such as:

1. yards – front and back – gardens, terraces, or patios of dwellings;
2. common outdoor areas allocated for recreational purposes – areas outside apartment buildings, condominiums, group homes, and hospitals;
3. parks and open spaces allocated for quiet recreational purposes within a subdivision.

When placing such areas where the enjoyment of the outdoor environment is important, consideration should always be given to shielding them from intrusive sound. Considering a townhouse development, front and back yards are customarily provided for each unit. The back yard is designated for the exclusive use of the resident and is the area the resident depends on for outdoor recreational activities. Thus, the back yard should be shielded and placed with the townhouse between it and the source of noise. The front yard is usually considerably less important than the back yard (Figure 3).

This technique, which requires a single-side use internal road and near-continuous row townhousing, provides a large degree of protection from noise for both the back yards and housing behind the barrier row. An alternative technique (Figure 4) has a more conventional layout with a two-side-use internal road and single-family residences. The back yard is protected by a barrier – berm, wall, or combination. This technique, though useful, is not as effective as the first, since berms or walls can only be built to a certain height because of structural and aesthetic considerations. Further comments and ideas on the use of berms as a noise-control measure are presented in the following section.

5.2 Acoustical Barriers

An acoustical barrier is either a planned or natural obstacle, placed between the source of the noise and the sensitive land-use or residential unit which interrupts or impedes the propagation of the emitted sound waves. Acoustical barriers are a useful and practical method of reducing noise. Natural barriers include significant topographical variations between the source and the receiver, and existing intervening structures or buildings. Planned barriers may include earth berms, walls, or buildings. Obviously, the choice from among the alternatives depends on considerations such as space, cost, safety, aesthetics, and the desired level of noise reduction.

The expected level of noise reduction due to the barrier depends on the path length difference it provides plus the extent and mass of the barrier. To be effective, a barrier should be positioned as close as possible to either the source or the receiver in order to maximize the path length difference for a given barrier height. The barrier may well be required to provide attenuation for a receiver in an outdoor recreational area or on a balcony at an elevated level in a residential unit.

In general barriers must be long and continuous, or alternatively, wrapped around the area to be protected thus preventing sound from passing around the ends. To provide the maximum decrease in noise level, the barrier must be solid, without holes, gaps, or

Figure 3

Recreational Area (Backyard) Shielded by the Townhouse Structure

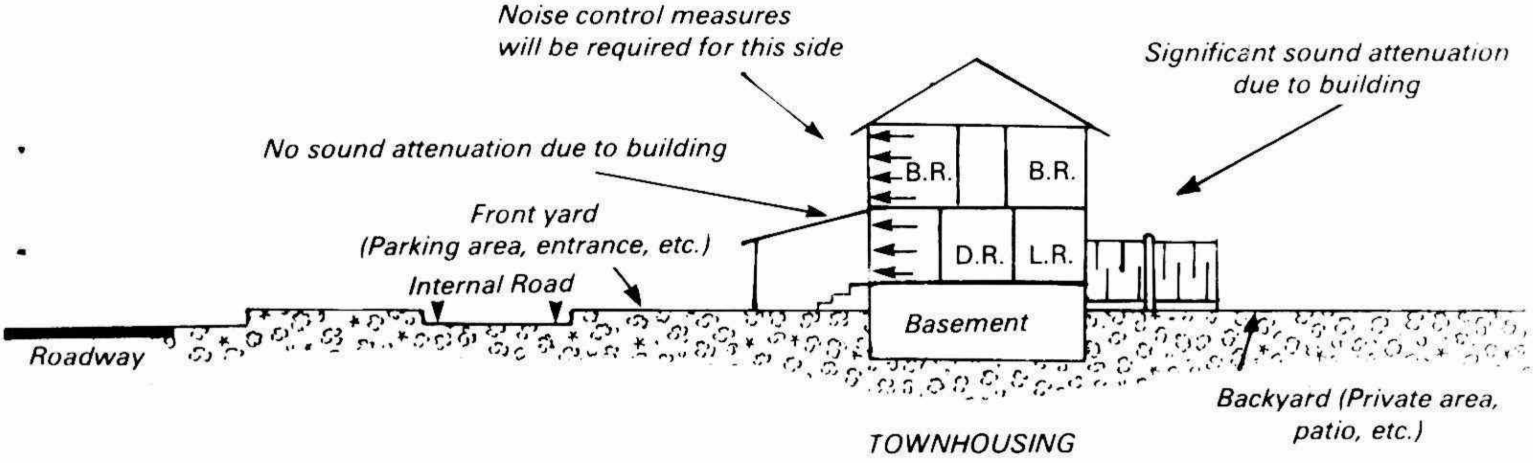
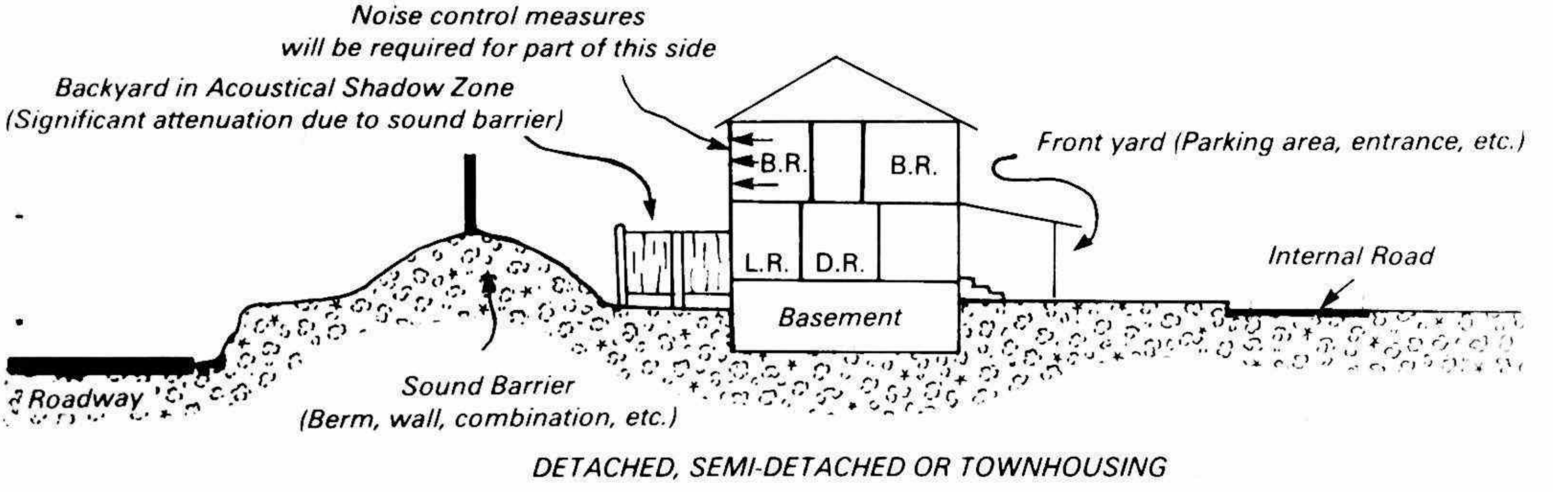


Figure 4

Recreational Area (Backyard) Shielded by a Sound Barrier


Noise control measures
will be required for part of this side
Backyard in Acoustical Shadow Zone
(Significant attenuation due to sound barrier)
B.R.
B.R.
Front yard (Parking area, entrance, etc.)
L.R.
D.R.
Internal Road
Basement
Roadway
Sound Barrier
(Berm, wall, combination, etc.)
DETACHED, SEMI-DETACHED OR TOWNHOUSING

openings. Some barriers offer the option of having a sound absorptive surface on the noisy side to lower sound levels further. Safety is an important factor in barrier construction which may necessitate consideration of such requirements as stability, visibility at roadway intersections, and the use of guard or crash rails on high-speed roadways.

The detailed design and construction of a noise barrier, such as a berm or wall, requires consideration of cost of installation, structural stability, strength, durability, servicing, and maintenance, as well as the other factors discussed above. Topographical changes in site contours to achieve additional noise control should be considered in the early planning stages.

5.2.1 Earth Berms

Berms up to 15 feet in height are considered satisfactory aesthetically although some reports cite heights of 50 feet as being the upper limit. The higher the berm, the greater the width of land required for construction. Normally, the width is six times the height. Because of the amount of land required, a berm is not always the most feasible method of reducing traffic noise.

Earth berms possess the advantages of:

a. deflecting the sound waves upward (instead of reflecting them from one side of the source to the other) which reduces the noise perceived on the opposite side;
b. providing absorptive surfaces (as compared to bare walls) on both sides of the source which further reduces the intensity of the reflected sound waves;
c. meeting minimum mass requirements without difficulty;
d. providing a more appealing and aesthetically pleasing acoustical barrier for the residents;
e. providing space for terraced gardens or recreational and play areas.

Care must be taken, however in landscaping berms, particularly with respect to trees and shrubs which may scatter sound waves downwards and cancel at least part of the sound attenuation berms provide.

Insufficient space may exist to construct a berm up to the height required. In this case, a berm/wall or berm/fence combination may be used. For instance, if a 14-foot berm is required, space could be saved by using a six-foot, solid, wooden fence on top of an eight-foot berm.

5.2.2 Barrier Walls and Fences

Acoustical barrier walls and fences exist in many designs and material variations. Basically, any solid continuous structure of an adequate mass without holes or gaps will suffice as a barrier. The advantages of walls and fences are that they require a minimum of space and maintenance. They also provide privacy and physical separation from the noise source when desired, such as keeping people from entering a highway, railway tracks, or industrial property. One disadvantage of walls or specially designed fences is that great lengths of high structures, do not have a pleasing appearance.

5.2.3 Intervening Structures

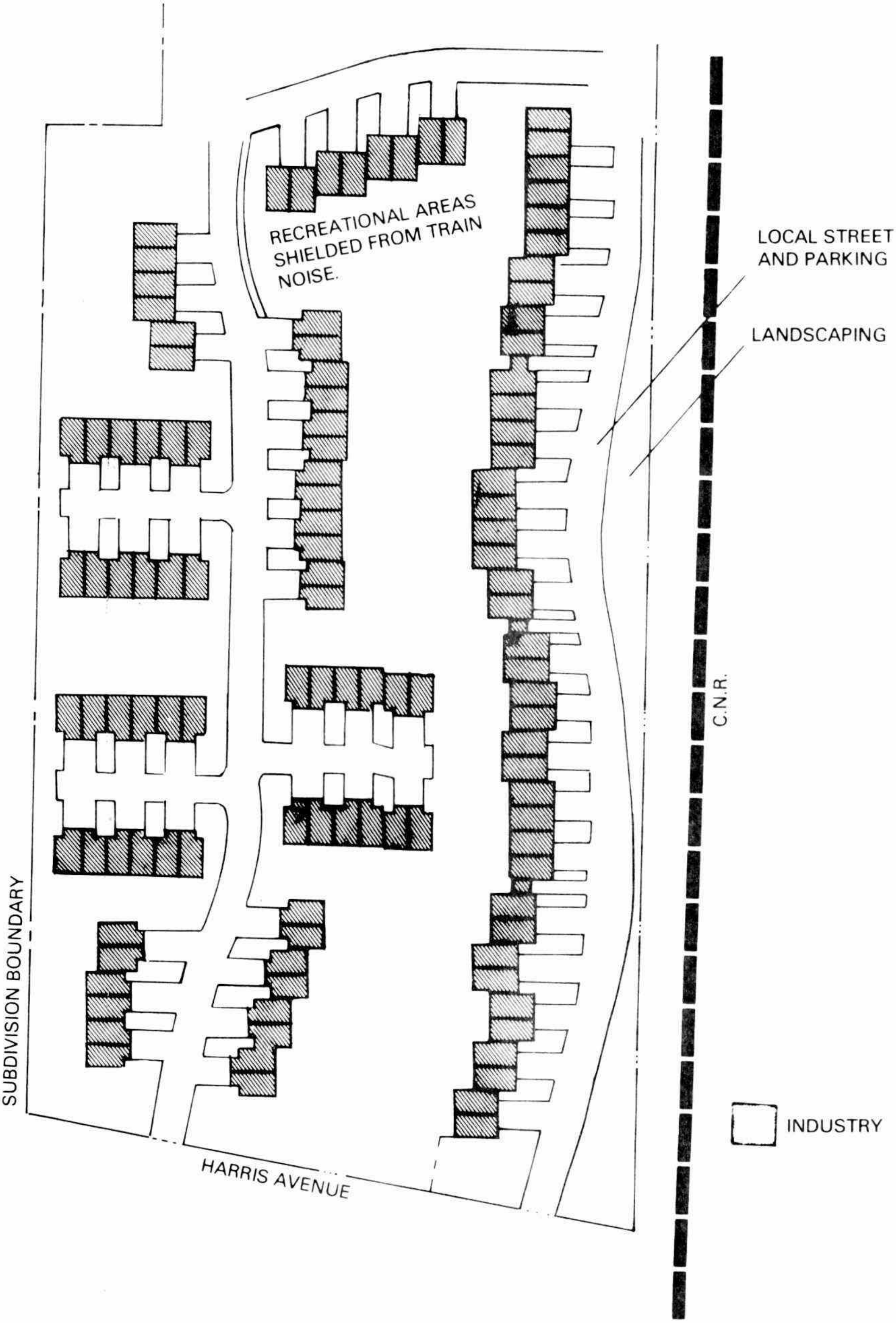
In built-up areas, the first row of buildings facing a source of noise can be used as "barrier blocks" to reduce noise levels for areas beyond. Using intervening structures as a site-planning technique to control noise can often be very effective. Planners and designers should be encouraged to utilize appropriate forms of buildings or structures to create acoustical shielding. This technique is gaining wider acceptance and is applicable to redevelopment in densely populated areas where there is a shortage of land for residential use.[15]

Barrier blocks offer a great advantage by fulfilling a useful role in protecting a site and by providing a residential or commercial land use. The blocks often do not need to be excessively high to be effective. With medium-density projects, a well-designed barrier block three to four storeys high, consisting of single aspect or "one-sided" dwellings may reduce external noise to an acceptable level throughout a site.

To be fully effective, barrier blocks must be continuous and as close as possible to either the source of the noise or to the sensitive area. For a given height of a barrier block, the closer the block is to the source, the smaller the area wasted on the noisy side of the barrier. If a barrier building is used to protect a site, however, consideration must be given to protecting the indoor environment of these buildings from noise transmitted from the source side. Special glazing, ventilation, and internal building arrangements are common forms of protection.

An effective barrier block design is shown in Figure 5. This example shows a continuous row of townhouses located on the site parallel and close to the railway tracks. Similarly, other continuous townhouse units are at right angles to the tracks and parallel to the local street to shield the site from road traffic noise. Walls that are perpendicular to a line source will be subjected to noise levels only slightly less than walls that face the source. These walls should be blank.

If blank walls are used in medium and high-density residential developments such as single and multi-stacked townhouses and apartment blocks, the buildings will have to be single aspect. In some cases, individual units could be slightly wider than conventional units to allow lighting and ventilation from one side only. This approach should not, however, present undue difficulty to the architect and designer. In many cases, internal layouts similar to those in double aspect or "two-sided" apartment blocks or in back-to-back townhouses, where each dwelling unit has only one front, can be used. For single-front dwelling units, standard techniques are widely used for ventilation and lighting from one side only. Special design considerations are unnecessary for these factors. Where extensive use of blank walls is undesirable for practical or aesthetic reasons, windows can be introduced into the noisy facade of the building, so long as the glazing gives adequate sound insulation.



NO. OF TOWNHOUSE UNITS = 116

FIGURE 5: EFFECTIVE USE OF BARRIER BLOCKS TO SHIELD SITE FROM TRAIN NOISE.

5.2.4 Room and Corridor Arrangement

Noise impact can be reduced by separating noise-sensitive rooms from less noise-sensitive rooms, and by placing the former in the part of the building furthest away from the traffic noise. Less sensitive rooms or spaces should then be placed closest to the noise source to act as buffers for the more sensitive rooms. The latter typically include bedrooms, living rooms, recreation rooms, and dens, where activities such as sleeping, talking, watching televison, listening to music, and relaxation demand a quieter environment. Kitchens and bathrooms are not as sensitive as the rooms already mentioned, but should be classed as noise sensitive in any case; kitchens, in particular, are often occupied for a considerable portion of the day, especially when used for eating. Noise-insensitive rooms or spaces include corridors, stairways, separate entrances, garages, storage, and garbage areas.

Extreme care must be exercised when designing a barrier block to avoid undue exposure to noise of dwelling units placed close to the ends of the barrier building. Passageways and gaps between the barrier buildings must be minimized because they can negate the effectiveness of the barrier.

5.3 Architectural Design

The architect and designer can use broad and effective noise-control measures to achieve a satisfactory indoor environment in any building. The techniques described in this section are alternatives to, although sometimes they complement, the special construction techniques discussed below. It may often be best to consider architectural design first in order to avoid the necessity of special construction features.

5.3.1 Blank Walls and Windows

Since blank walls, solid masonry, or concrete walls significantly reduce sound waves passing from outdoors to indoors, they represent a simple method of achieving a satisfactory indoor noise environment, despite the presence of an unsatisfactory outdoor environment. If conventional windows are placed in a blank wall, the attenuation of sound produced by the wall/window combination is considerably reduced since glazing attenuates sound poorly. In a barrier building, blank walls facing the source are preferred, with windows put in the other walls (Figures 6 and 7).

5.3.2 Balconies, Terraces, and Courtyards

Balconies, terraces, and courtyards located outside dwelling units for the enjoyment of the outdoor environment should not be subjected to unduly high noise levels. Certain types of balconies facing a roadway may reflect noise directly into the interior of the building. Such problems are particularly applicable to high- and medium-rise apartment buildings and stacked townhousing. If balconies and terraces are desired, the architect should avoid noise problems by placing the balconies on the quiet side of the building. Siting buildings to reduce noise problems is possible for stacked townhousing where the terrace or balconies can be moved from the front to the back or *vice versa*

Figure 6

The Use of Blank Walls for an Apartment Building or Stacked Townhouse

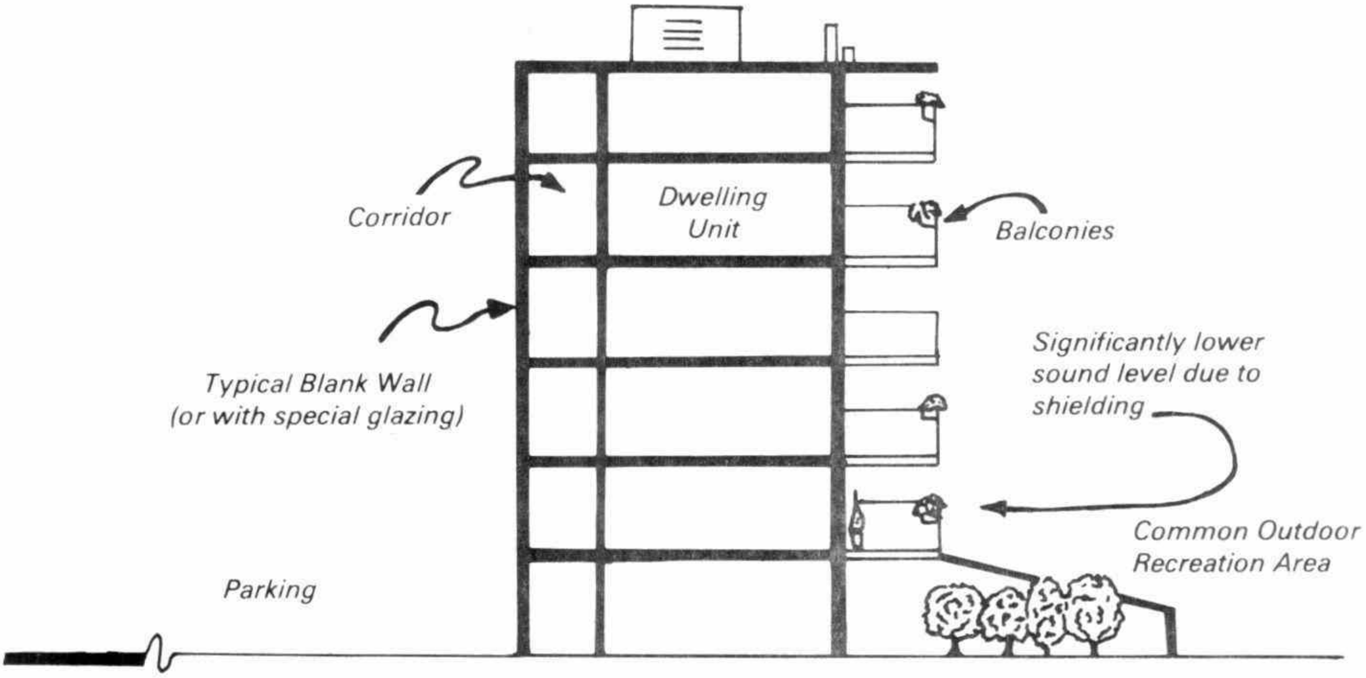
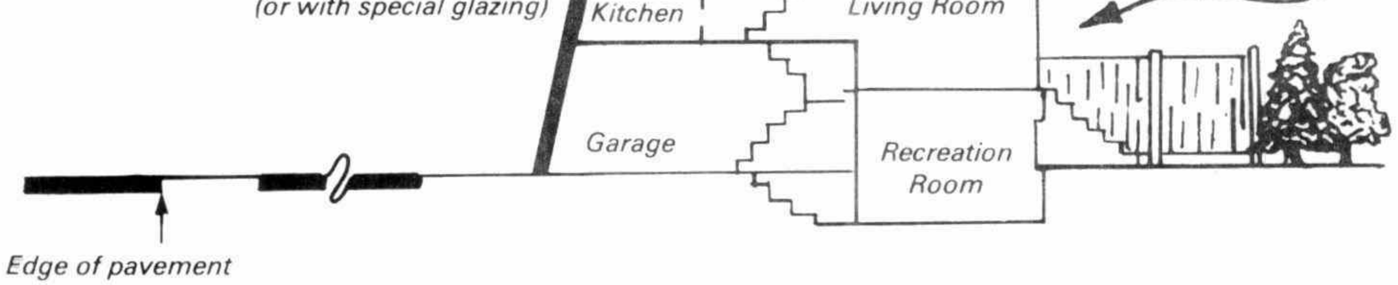

Corridor
Dwelling Unit
Balconies
Typical Blank Wall (or with special glazing)
Significantly lower sound level due to shielding
Common Outdoor Recreation Area
Parking

Figure 7

The Use of Blank Walls for a Townhouse


Conventional Day Lighting and Ventilation
Bedroom
Significantly lower sound level due to shielding
Bedroom
Dining Room
Blank Wall (or with special glazing)
Kitchen
Living Room
Garage
Recreation Room
Edge of pavement

(internal arrangements perhaps being changed to suit). When this solution cannot be applied in dual-aspect or double-loaded buildings, however, other solutions, such as providing a common outdoor recreational area shielded by the building instead of balconies, should be investigated.

5.4 Construction Techniques

As stated above special construction techniques are often alternatives to architectural design and fulfill very similar roles. These techniques often allow protection of the indoor environment of a residential unit of conventional design. In some cases, both special construction techniques and architectural design can be used to achieve an acceptable living environment.

5.4.1 Acoustical Treatment of the Building Facade

Acoustical treatment of a building facade which faces a noise source or is at such a height as to remain unprotected by a barrier or barrier building is an alternative to the approach discussed above. A blank wall will usually provide sufficient insulation to ensure a reasonable indoor environment. However, if windows or any other openings are introduced into the wall, the attenuation could be greatly reduced. To avoid this possibility, the facade glazing and openings should be carefully designed to ensure sufficient attenuation to give acceptable indoor noise levels.

Methods of obtaining sufficient noise attenuation from a window are:

a. seal standard windows in the building facade;
b. reduce window size;
c. increase the glass thickness;
d. use double- or triple-glazed windows with the appropriate width of air space between panes.

Acoustical treatment of building facades are dealt with in more detail in specialized design guides.[16 17]

5.4.2 Quality of Construction

The need to consider the quality of construction cannot be stressed sufficiently when trying to achieve attenuation of noise indoors. The effectiveness of the positive, structural, noise-control measures discussed above may be reduced by poor workmanship, improper jointing, caulking, and general neglect of good acoustical insulating practices. The principles used in energy conservation practice apply to the achievement of satisfactory acoustical insulating qualities of the structure.

5.5 Dealing with Slight Noise Problems

Often, the assessment of noise levels at a particular site will indicate a slight noise problem (less than 5 dB). Such an excess is recognized as being "just noticeable." Whether a developer should be asked to provide physical noise-control measures to

Figure 8

Indoor and Outdoor Noise Control Measures and Their Timing in the Subdivision Planning Process

Noise Control Measures

Measures to Specifically Reduce Outdoor Noise Levels		Measures to Reduce Indoor Noise Levels	
Early Consideration in Planning Process	Late Consideration in Planning Process	Early Consideration in Planning Process	Late Consideration in Planning Process
- Distance Setback	- Earth Berms	- Blank Walls	- Blank Walls
- Insertion of Noise Insensitive Buffer Zones	- Barrier Walls and Fences	- Room and Corridor Arrangement	- Room and Corridor Arrangement
- Orientation of Outdoor Recreational Areas		- Orientation of Windows	- Orientation of Windows
- Favourable Topographical Features as Barriers		- Special Acoustical Treatment of Walls, Windows, Doors and Roofs	- Acoustical Treatment of Walls, Windows, Doors, and Roofs
- Earth Berms			
-Barrier Walls and Fences		- Air Conditioning and Ventilation	- Air Conditioning and Ventilation
- Intervening Structures as Barriers			
- Orientation of Balconies and Terraces			

Note:

1. Outdoor noise control measures also generally reduce the indoor noise levels.

2. Measures considered during early planning process are generally more acceptable aesthetically and cost very little.

remove such a problem is debatable. In such cases, however, consideration should be given to longer term aspects of the situation. The developer may be asked to remove the small excess or prospective purchasers of such lots may need to be informed that a slight noise problem exists. A "warning clause" system has been used in Ontario. Unfortunately, it is sometimes difficult to ensure that a would-be purchaser reads such a clause before making a commitment to buy. This difficulty is particularly true for second and subsequent purchasers. A similar clause should be included in Rental Agreements and be read by the prospective tenant before an agreement is signed or a commitment made.

5.6 Effect of Timing on Site Noise-Control Measures

In Figure 2, site noise-control measures available to the developer are summarized in terms of the options open to investigation at the conceptual stage of a new subdivision. These options do not, however, take timing and opportunity costs into account. A corollary of efficient site design is that noise-control measures instituted as an afterthought or as a result of an official requirement to meet a lower noise level on the site may cost more than anticipated. Figure 8 illustrates this point. Measures that may be given late consideration in the site planning process are listed.

5.7 Summary of Land-Use Noise Controls

This chapter outlined the planning process in Alberta and Ontario, where for several years noise has been a concern in the planning process. Given staff suitably trained in acoustics, concerns about noise can be injected into planning without specific legislation and can easily be considered along with other aspects of planning. In Ontario, a progressive development of the procedures and guidelines took place over a period of time. A similar development phase would likely occur in other provinces, if noise were considered part of the planning process.

6. ONTARIO GUIDELINES ON NOISE CONTROL FOR DEVELOPERS

The purpose of these guidelines is to ensure that sufficient data is made available by the developer to the approving authority demonstrating that the objective of lowest feasible sound levels for new residential development has been achieved. The analysis and evaluation by the approving authority will consist of checking the validity of the submission based on the best available acoustical information.

The information required to review and evaluate proposals for new residential development should also include the following:

1. *Location of freeways* – The plans should indicate existing or future location of freeways.
2. *Site plan* – Site plan should show the topography of the site, elevation, and layout of the various existing buildings or proposed structures.
3. *Establishing the sound levels on site* – The sound levels anticipated on the site should be established by the use of prediction techniques acceptable to the approving authority based, if necessary, on on-site measurements. In all cases, consideration should be given to anticipated future increases in sound levels for at least ten years.

4. *Sound attenuation measures* – When predicted sound levels on the site of the new residential development exceed the objective sound levels, the developer must investigate the feasibility of achieving the levels required by provincial policy.
5. *Noise from freeways* – The tables not/ attached[19] provide preliminary information on predicted excess noise expressed in decibels above the objective sound level for average freeway traffic conditions.* Current AADT traffic counts for any particular freeway may be obtained from the Ministry of Transportation and Communications publication, "1976 Traffic Volumes -- on the King's Highway and Secondary Highways."[18] The AADT traffic count, for the purpose of using the attached tables to determine the predicted decibel excess above the objective sound levels, must be multiplied by a suitable factor to account for traffic conditions expected ten years hence. Developers may obtain further information on traffic counts and noise prediction techniques from the regional offices of the Ministry of the Environment or from the Noise Pollution Control Section, Toronto.
6. *The publications* "Acoustics Technology in Land Use Planning":
    Vol. I – Analysis of Noise Impact[14]
    Vol. II – Road Traffic Noise Tables[15]

   may be obtained by writing to:

    Ontario Government
    Publications Centre
    880 Bay Street, 5th Floor
    Toronto, Ontario M7A 1N8

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* The predicted excess noise may also be derived by consulting CMHC documents.[8, 17] These tables should be used where it is necessary to estimate the noise impact on highrise developments at moderate or large setbacks.

7. REFERENCES

1. U.S. Environmental Protection Agency. 1974. *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety,* Document 550/9-74-004. Washington, D.C.: Environmental Protection Agency.

2. Associate Committee on Scientific Criteria for Environmental Quality. 1976. *Effects of Noise on Man,* NRCC 15383. Ottawa: National Research Council.

3. Schultz, T.J., Galloway, W.J., Beland, D., and Hirtle, P.W. 1976. *Recommendations for Changes in HUD's Noise Policy and Standards,* BBN Report 3319R 1976 (Restricted).

4. National Academy of Scienc . 1977. *Guidelines for Preparing Environmental Impact Statements on Noise,* Report of Working Group 69. Washington, D.C.: National Academy of Sciences.

5. Schultz, T.J. 1972. *Noise Assessment Guidelines, Technical Background,* prepared for USHUD, Office of Research & Technology, BBN Inc, HUD Report No. TE/NA 172 BBN No. 2005R. Washington, D.C.: Department of Housing and Urban Development.

6. Gidamy, H. and Hemingway, J.R. 1977. *Setting and Refining Sound Level Limits for New Residential Development.* Toronto: Ministry of the Environment.

7. Ministry of the Environment. 1978. *Model Municipal Noise Control By-Law: Final Report.* Toronto: Ministry of the Environment.

8. Central Mortgage and Housing Corporation. 1978. *Road and Rail Noise: Effects on Housing,* Ottawa: Central Mortgage and Housing Corporation.

9. International Standardization Organization. 1971. *Assessment of Noise with Respect to Community Response,* Recommendation R 1996.

10. Ministry of the Environment. 1977. *Submission Guidelines on New Land Use with Respect to Noise.* Toronto: Ministry of the Environment. (Appendix 1).

11. Hemingway, J.R. 1976. "Development of a Model for Predicting Train Pass-By Noise Profiles." *Acoustics and Noise Control in Canada,* Vol. 5, No. 4, p.21.

12. Hajek, J.J. 1976. *An L_{eq} Traffic Noise Prediction Method.* Toronto: Ministry of Transportation and Communications.

13. Ministry of the Environment. 1978. "Acoustics Technology in Land Use Planning," in *Information on Courses and Workshops.* Toronto: Ministry of the Environment.

14. Ministry of the Environment. 1978. "Analysis of Noise Impacts," in *Information on Courses and Workshops.* Toronto: Ministry of the Environment.

15. Ministry of the Environment. 1978. "Road Traffic Noise Tables," in *Information on Courses and Workshops.* Toronto: Ministry of the Environment.

16. Department of Environment. 1972. *New Housing and Road Traffic Noise,* Design Bulletin 26, H.M.S.O. London: Department of Environment.

17. Central Mortgage and Housing Corporation. 1977. *Residential Standards: Building Design Guides.* Ottawa: Central Mortgage and Housing.

18. Ministry of Transportation and Communications. *1976 Traffic Volumes on the King's Highways and Secondary Highways.* Toronto: Ministry of Transportation and Communications.

19. Ministry of the Environment. 1978 rev. *Sound Levels of Road Traffic: Model Municipal Control By-Law,* Publication NPC-129. Toronto: Ministry of the Environment.

Traffic Noise Control in Land Use Planning

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ABSTRACT

The paper outlines the development of the Ontario Ministry of the Environment approach to planning with respect to road traffic noise. Since 1974, the Ministry of the Environment has routinely examined all new projects potentially impacted by noise, pursuant to the existing legislation. In 5 years more than 2000 land use applications, representing a small fraction of the total, have been specifically examined because potential noise impacts have been recognized or anticipated. Potential noise problems are being identified by reliable prediction techniques based, when necessary, on actual measurements and site inspection. When anticipated sound levels on the site of the land-use development under consideration exceed the allowable sound level limits, the land developer is asked to institute appropriate control measures or revision to plans. The Ministry of the Environment has, over the past six years, developed broad source-oriented and receiver-oriented environmental noise control programs that cover regulation and policy development, standards setting, enforcement, training and the assessment of new land uses and new projects. The discussion in this paper is limited to the receiver-oriented noise control program aimed at reducing the impact of vehicular traffic noise during the various stages of the planning process.

An attempt is made to describe the eight components of the Ontario land use planning program to control noise. The components include legislative power available, the planning process at various levels of government, sound level objectives, identification of feasible noise control measures, preparation of technical publications, administration of an educational program, establishing review and enforcement procedures and audit program to gauge the effectiveness. Since these steps and objectives have proven to be successful over the past four years, they are offered as basic components of a land use planning program to control noise in other jurisdictions.

NOISE CONTROL IN LAND USE PLANNING

1.0 INTRODUCTION:

There is a growing concern for the way that we use land. Planners, engineers, environmentalists and legislators are being challenged to create land use plans that will provide a controlled and healthy environment for present and future generations. As a result of the growing concern for the quality of the environment, land use planning is becoming one of the major areas of interest to ensure that the necessary environmental safeguards, including those controlling undue noise impacts, are incorporated into land use policies and programmes at all levels of government and in the private sector. Careful planning is necessary to account for the conditions as they exist today and for the many years in the future and to account for the continued growth and changes in our living and physical environment.

The basic philosophy of traffic noise control in land use planning is to avoid future noise problems and complaints by either placing new residential (or other noise sensitive) areas away from existing noise sources or new noise sources away from existing residential areas.

Transportation noise sources, particularly vehicular traffic, are major sources of environmental noise pollution which may have an impact on the quality of life in populated areas. The effect of traffic noise on the urban environment is becoming an increasingly important consideration since noise is capable of interfering with human efficiency, personal comfort and the enjoyment of property.

Traffic noise seems to be the dominant transportation noise problem with railways a close second. Not only does the network of highways and railway tracks spread across Canada but the implication of noise from these sources on new development is worsened because these developments are more likely to occur close to the transportation corridors themselves due to the pressure for new development in developed urban areas.

Both road and rail noise sources are restricted to ground level which makes control of their noise easier than that from aircraft or predominantly air-borne sources. For aircraft noise very little can be done for the outdoor environment apart from placing adequate distances between noise sensitive land use and the aircraft flight path.

2.0 NOISE AND THE PLANNING PROCESS:

It may well be thought possible under this heading to discuss what would be the ideal planning process as far as noise is concerned. The difficulties in attempting this are several, first the planning process cannot be wholly oriented towards a single facet such as noise. The planning process must necessarily cover many and often contradictory concerns such as air pollution, water pollution, sewage services, housing demand, marketability, economics and politics. No matter what the acoustical expert feels is best, the final decisions rest with the planning experts and politicians who must of necessity take a broader view.

Another important reason is the fact that a planning process does not appear over night, rather it is a gradual process of refinement and hopefully, improvement. The acoustician must take his place alongside others in this refining process, although he may have to work a little harder in order to catch up with other long established land use planning considerations. He must ensure that his concerns can at least be presented and considered within the evolving planning process.

As land use planning in Canada is recognized as basically a local matter and as such is handled by the Provincial level of government (with delegation to the Municipal level in some cases), it follows that there will be some ten Provincial planning processes all in various stages of refinement and perhaps moving in different directions. In this paper, the provincial planning process in Ontario will be examined since noise considerations have been part of the planning process for several years. Although the Ontario planning process will be discussed here, it should not be thought that it is being presented as the ultimate model. After several years of eduction and injecting noise considerations into the planning process it has been the experience in Ontario that the approval procedures must be further streamlined, bureaucracy minimized and suitable staff hired and used to the full. The Planning Act is also presently under review. To put it simply, the process of refinement goes on.

3.0 A PROGRAM TO CONTROL TRAFFIC NOISE IN LAND USE PLANNING:

Since 1974, the Ontario Ministry of the Environment has routinely examined new projects for noise impact, pursuant to the existing legislation. In five years more than two thousand new land use applications, representing a small fraction of the total, and a lesser number of industrial and commercial project applications have specifically been examined because potential noise impacts have been recognized or were expected.

It is interesting to trace the genesis of the Ontario noise control program as it has evolved from the time the Ministry of the Environment was reorganized in April 1974. It was then that the Noise Pollution Control Section was established as a separate technical unit within the Pollution Control Branch of the Ministry. Prior to April 1974, noise control was a responsibility of the Air Management Branch and before that the Public Health Department of the Ministry of Health responded to noise complaints lodged by the public.

The Ontario Ministry of the Environment has, over the past six years, developed a broad, source oriented and receiver oriented, environmental noise control program that covers regulation development, standards setting, the assessment of new land uses and new projects, enforcement and training.

Due to the limited space available in this paper, the discussion will be limited to the receiver oriented noise control program administered by the Ministry. For information on source oriented noise control programs administered by the Ontario Ministry of the Environment and other agencies References 1, 2 and 3 may be consulted.

4.0 THE NEED TO CONSIDER NOISE DURING THE PLANNING PROCESS:

The Planning Act (Reference 4), administered by the Ontario Ministry of Housing provides a statutory framework for land use planning and implementation at the local government level throughout the Province of Ontario. The focal points in The Planning Act dealing with the effects of noise on the inhabitants of an area are clearly and simply stated in Sections 1 and 33 of the Act wherein the concern for public health, safety, convenience and welfare is stressed.

The Environmental Protection Act, 1971 (Reference 5) administered by the Ontario Ministry of the Environment deals explicitly with noise and vibration as contaminants of the natural environment which may cause harm or material discomfort to any person, or render any property unfit for use by man or animal.

In general, there is a need to consider noise early in the planning process for the following reasons:

(i) Noise causes adverse effects on human beings including interference with conversation, study or work activity, relaxation and resting, sleep, and other human activities.

(ii) The benefits far outweight the cost of incorporating noise measures in the earlier planning stages such as the approval of Official Plans, Zoning By-laws, etc. compared to remedial work mandated after the fact.

(iii) The existence of major and difficult noise sources such as airports and major transportation corridors. Unfortunately, the flexibility available to environmental managers to control such noise sources is very much limited due to the tremendous cost involved in achieving even minimal sound reductions.

(iv) To avoid later conflicts with other competing planning considerations such as the use and density, orientation, storm and sanitary drainage.

5.0 COMPONENTS OF THE LAND USE PLANNING PROGRAM TO CONTROL NOISE:

In the following paragraphs an attempt will be made to outline the development of the Ontario Ministry of the Environment's approach to planning with respect to noise, particularly surface transportation noise.

Figure 1 illustrates the objectives and the planned program development sequence in the Noise Pollution Control Section in 1975 when a new unit was created within the Section to evaluate and comment on land use proposals. As these program objectives have proven to be successful over the past four years, we offer them in this technical paper as basic components of a land use planning program to control noise.

5.1 LEGISLATIVE POWER

As a first step, one must study existing means of exercising power or some form of control through Acts, regulations, government policies, codes, guidelines, etc. The inventory of such instruments to accomplish the final objective should be classified according to their application; whether source oriented, or receiver oriented.

In Ontario, The Planning Act, administered by the Ministry of Housing, provides for the preparation, adoption, approval and legal effect of two planning tools, the Official Plan and the Redevelopment Plan. The Act establishes a system of subdivision control and it delegates to local and regional municipalities power to enact zoning by-laws and to implement the provisions of the statutory plan. It also describes procedures for obtaining central government approval by the Minister of Housing or the Province's administrative agency, the Ontario Municipal Board, for local planning and land use control decisions. Although The Planning Act implies Ministry of Housing responsibility for the development of residential developments, the Ministry is, in fact, responsible for the overall and general planning of all land uses including industrial, commercial, agricultural and rural land uses. Therefore, it may be concluded that The Planning Act is both source and receiver oriented legislation when dealing with environmental issues including noise pollution, especially at the earlier stages of the planning process when large tracts of land are designated for various uses.

It should be noted that the Act provides planners with broad power to control the development of incompatible land uses and that it does not contain any specific criteria for new noise sensitive developments. In fact, most of the specific criteria developed for evaluation of noise in new land use planning are contained within local policies developed by municipalities using the broad powers and provisions of The Planning Act. Good examples of such policies include the extensive noise policies dealing with surface transportation and aircraft noise in the Draft Official Plan of the City of Mississauga (Reference 6) and Draft Official Plan of the City of Brampton (Reference 7).

The Environmental Protection Act (Reference 5) and The Environmental Assessment Act (Reference 8) administered by the Ministry of the Environment deal with noise and vibrations as contaminants of the natural environment and both Acts provide for the protection and conservation of the natural environment. The Environmental Protection Act exercises control over the emission of noise from noise sources by prohibition, control orders, stop orders, work orders, approvals, thus the problem of noise is tackled at the source rather than the receiver. For planning purposes, the provisions for approval of new sources of noise pursuant to The Environmental Protection Act are worthwhile noting as they affect the use of a particular property or tract of land. A use which may render adjacent properties incompatible.

The Environmental Assessment Act, another Act passed for the betterment of the people of Ontario, provides for the protection and conservation of the environment and wise land management. The Act applies to enterprises, activities, proposals, plans or programs that may affect the natural environment. In particular, the development of new surface transportation corridors or systems, or expansion of existing facilities would normally be subject to the provisions of The Environmental Assessment Act. Already several proposals for new highway projects and transit systems in Ontario have been the subject of examination with respect to their noise potential.

Concerning other noise policies in Ontario, the Ontario Ministry of Housing in cooperation with the Ontario Ministry of the Environment and the Ontario Ministry of Transportation and Communications have proposed a new provincial policy on new residential development adjacent to freeways (Reference 9). The new noise control policy deals with the approval of new residential developments adjacent to freeways, as well as the development of new freeways in Ontario. It outlines a basic framework for adoption and application of specific noise policies and noise criteria when dealing with a specific situation.

Earlier in March 1978, the Ontario Ministry of Housing in cooperation with the Ontario Ministry of the Environment prepared a land use policy for lands near airports based on the noise exposure forecast (NEF) system (Reference 10). This policy contains a land use compatibility table outlining acceptable land uses within given noise exposure forecast (NEF) values and the required acoustical insulation, if needed.

Furthermore, the Ontario Ministry of the Environment has prepared numerous guidelines on planning with respect to noise. The interim guidelines were used during 1975 and 1976, and were later revised in July 1977 as part of a land use planning procedures manual dealing with noise. (Reference 11). The manual is believed to be the first comprehensive noise document in Canada to deal with specialized and specific land use planning problems. The guidelines contained in the manual are basically receiver oriented in nature.

In 1975, the Ministry of the Environment also published a Model Municipal Noise Control By-law for adoption by local municipalities in Ontario under the enabling legislation, The Environmental Protection Act. The Model Municipal Noise Control By-law, Final Report, (Reference 1) contains several guidelines for the benefit of those concerned with land use planning. Here the guidelines are aimed at both receiver and noise oriented land use planning problems.

5.2 THE PLANNING PROCESS AT THE VARIOUS LEVELS OF GOVERNMENT

This discussion outlines the role of the various levels of government as they may affect land use planning in Ontario. The Federal Government, although it does not have direct control as does the Provincial Government, can influence land use planning by its legislation, policies and programs on such matters as transportation, resource development, funding and land acquisition. The location of airports as well as the funding of new housing adjacent to airports are examples of how the Federal Government can influence land use planning.

Legislation recently tabled in Parliament will seek to give the Federal Government control over land uses near an airport unless this power is being exercised by the provincial government and municipalities concerned.

Two particular Federal Government policies and programs are worth noting. The C.M.H.C. funding of new housing developments adjacent to roadways and railway tracks (Reference 12) and the funding of new housing developments around airports (Reference 13). Both programs are related to the Central Mortgage & Housing Corporation's obligation to secure its direct financing under the National Housing Act. It must be emphasized here that although the C.M.H.C. standards apply to new housing development under these programs, they do not greatly affect land use planning at the provincial and local levels.

Concerning the planning process at the provincial and local levels, it is extremely important that one understands the various steps and processes involved as they provide the vehicle for implementation and enforcement of noise policies related to land use planning. The planning process in Ontario involves a sharing of responsibilities between the provincial government and the upper and lower tier municipalities.

The planning process in Ontario involves the preparation of Official Plans and amendments thereto, Secondary Plans, Neighbourhood Plans, zoning by-laws, and subdivision plans. Ultimately, building plans are then submitted to the building departments of local municipalities for issuance of a building permit.

Official Plans are prepared by Regional and Local Municipalities outlining the program and policy for the planning area under consideration. The Draft Plan is then submitted to the Minister of Housing for approval (examples are References 6 and 7). Prior to granting this approval, the Ministry of Housing requests the Noise Pollution Control Sections' comments (in addition to those of several other agencies on the circulation list) which may be incorporated into their conditions for approval. These plans are conceptual rather than detailed. When the Official Plan is eventually approved by the Minister of Housing it is binding in that all future zoning by-laws, applications for Draft Plan of Subdivision, municipal undertakings and private sector developments must conform to the Official Plan.

Considerable time and effort goes into the preparation of an Official Plan before it reaches the stage where it can be submitted to the Minister of Housing for approval. The Noise Pollution Control Section is often called upon at this stage in the formulation of the Official Plan and the form of assistance provided is varied but can be in terms of advising on general policy, acceptable sound level limits, sound level prediction techniques, feasible noise control measures, etc. Clearly this circulation procedure allows noise concerns to be voiced at an early stage in the planning process along with other concerns of importance.

Secondary Plans, in general, contain the detailed implementation of the policies contained in the Official Plan. They describe the official policies concerning the physical, social, and economic development and redevelopment of specific areas within the planning areas of a municipality. Usually, Secondary Plans are prepared prior to consideration of development applications which makes them suitable for incorporation of specific and integrated noise control policies within the various parcels of land contained within such Secondary Plan. In fact, the most appropriate place in the planning process to consider noise control for "linear" sources of noise such as transportation corridors is during the formulation of Secondary Plans or Neighbourhood Plans.**

Draft Plans of Subdivision are submitted by the applicants to the Ministry of Housing or the Regional Municipality for approval. Prior submission is not mandatory, however, as a matter of prudence most prospective subdividers consult with the local or area municipality before formally submitting their applications. The Draft Plan is then circulated to those Ministries and agencies whose advice is required in order to evaluate the Draft Plan. As a result of the review by the approving agency, the Draft Plan of Subdivision may be approved as submitted, approved with conditions, turned down completely or with advice as to how it could be made acceptable. The review of a Draft Plan of Subdivision includes consideration of health, safety, convenience, and welfare of the future inhabitants. In the case of potential noise problems, copies of the Plan are forwarded to the Noise Pollution Control Section who appraise the situation using noise prediction techniques wherever possible.

If necessary, it is also recommended that the developer maintain close contact with the Noise Pollution Control Section in order to discuss and agree upon the noise control measures required to reduce noise levels on the site to acceptable levels. In the case of an adverse comment involving noise, it is very often made a condition of draft approval that the developer give an undertaking to incorporate acceptable noise control measures in the Subdivision Agreement and Plans pertaining to the site. The terms of the Subdivision Agreement are binding on the developer.

Concerning zoning by-laws, implementation of the Official Plan requires that the municipality apply to the Ontario Municipal Board for approval of the zoning by-law which legally restricts the land usage. The Ministry of Housing comments to the Ontario Municipal Board on the conformity of the by-law with the Official Plan or an amendment thereto after consultation, if necessary, with other interested agencies. Occasionally the Noise Pollution Control Section is called upon to advise on matters related to noise, or sometimes, appear as expert witnesses before the Ontario Municipal Board.**

It can be seen that under the Ontario system, although no specific legal requirements existed in the past to persuade developers to institute noise control measures per se, ways have been found to formalize the noise input under the broad provisions and powers of The Planning Act and other legal instruments such as the Subdivider's Agreement. This formalization has resulted from continuous input and refinement. Such refinement would, no doubt, also occur within the planning processes of other provinces if noise was accepted as being a matter of public concern.

**NOTE: The Ontario Planning Act is being revised and the official status of the Secondary Plan may change. Other changes such as an altered role for the Ontario Municipal Board are also contemplated.(Ref.22)

5.3 SOUND LEVEL OBJECTIVES

Before new residential developments can be designed to avoid problems caused by high environmental noise levels, sound level objectives and limits must be set to allow for an engineered solution in the form of noise control measures. Perhaps this is the most difficult part of the land use planning procedure with all the attendant implications. These limits are basically set as a compromise between two opposing influences; minimization of noise annoyance and minimization of the economic cost of noise control measures. The procedure for setting such sound level limits is relatively easy to define: choose the best noise rating method and then use that noise rating method to limit the community noise under consideration.

At this stage, however, one realises what a difficult task the setting of sound level limits can be. Numerous noise rating methods exist and papers are regularly published containing contradictory claims of the effectiveness of one rating method over another. Even after choosing one particular rating system, a limit must still be assigned above which the noise level may be deemed to be unsatisfactory. The fact that other pressures, namely economic and political, may confuse a decision made on simple health and welfare grounds does little to ease the task facing the acoustician. Perhaps recent attempts to define a single unified system for rating community noise may have greatly confused the issue.

After carefully considering various sound level descriptors as well as experimenting with them in land use planning, in complaint investigations and in the approval of new noise sources; the Noise Pollution Control Section in 1975 recommended the use of several sound level descriptors including L_{eq}, L_{50}, L_{90}, NEF, dBAI, and others depending on the application as indicated in References 1, 9, 10 and 11. For land use planning and surface transportation noise, the L_{eq} (for specific time periods) and the L_{50} are the main noise descriptors used.

In setting acceptable sound level objectives for new land use developments, the Noise Pollution Control Section adopted interim criteria in 1974 based on the results of a study prepared for the United States Department of Housing and Urban Development (HUD). That report (Reference 15) gathered together a large number of multi-national references on community noise measurements and sociological surveys on reaction to noise. Out of this considerable literature survey came a set of guidelines for urban noise assessment in the form of a set of cumulative distribution curves delineating "clearly acceptable" "normally acceptable", "normally unacceptable" and "clearly unacceptable" areas of noise exposure as shown in Figure 2. This set of cumulative distribution curves were intended to replace HUD's interim standards set out in policy circular HUD 1390-2 which were not expressed in a standard statistical format and could not be directly compared with other international standards (many of which were framed in terms of either the statistical distribution or median L_{50} levels). Further experimentation with the ranges suggested by HUD in the evaluation of new land uses in Ontario, clearly indicated the impracticality of using such wide and flexible ranges in assessing new land uses.

Figure 2 represents a single coherent set of sound level limits for delineating between "acceptable" and "non-acceptable" sound levels. These were successfully used in designing new residential subdivisions during 1974 and 1975. The sound level limits listed in Figure 2 were later simplified by picking off certain, often used, statistical descriptor levels from the curve such as L_1 , L_{10}, L_{50} and L_{90} in addition to the L_{eq} (Table 4 illustrates the levels corresponding to the Ministry of the Environment's design limit shown on Figure 3). The process of refinement continued during 1975 and this led to further simplification and the adoption of the sound level limits currently in use by the Ministry of the Environment as guidelines for evaluation of new residential and noise sensitive developments. For further details Reference 16 may be consulted.

The currently adopted sound levels for evaluating new noise sensitive uses are shown in Tables 2, 3, 4 and 5 (References 1 and 11).

6.0 IDENTIFICATION OF FEASIBLE NOISE CONTROL MEASURES

The term "Noise Control Measures" refers to the method of lowering indoor and outdoor sound levels to acceptable levels in residential and noise sensitive areas normally impacted by noise from surface transportation as well as industry.

Since noise was a relatively new field in Ontario as far as land use planning is concerned, it became obvious that something had to be done to increase the public level of knowledge on methods of noise control. Information which is scattered in the literature and text books. In the process of evaluating land use proposals within the planning process and the subsequent negotiations with land use planners and developers, an answer had to be found for the frequently asked question "Now that you have told us we have a noise problem, how can it be solved and how can we satisfy Ministry sound level requirements?".

As a result of the continuing discussion with Architects, planners and developers and the marrying of acoustical concepts to building design concepts several methods discussed below were evolved to stimulate the technology transfer and the educational process. Thus the Ministry's Acoustics Technology training program was born.

6.1 ACOUSTICAL SITE PLANNING TECHNIQUES AS NOISE CONTROL MEASURES

In general, physical methods to reduce noise impacts on new housing can be grouped into four major categories as shown in Figure 4. A very brief discussion of each group now follows.

Site planning means making use of the natural characteristics of the site, favourable surroundings, density of development, and zoning to reduce the noise impact on proposed development. Site planning measures are economical and very effective especially if they are considered early in the planning stages when the flexibility is still available.

6.1.1 DISTANCE SETBACK

For example, distance setback may be used as a physical separation between the noise source and the receiver. Distance setback is more suitable for rural land uses and it usually results in reducing both outdoor and indoor sound levels. Distance setback is also most suitable for the development of standard design high rise buildings and low cost housing if the developer does not wish to incorporate special glazing and air conditioning for the large number of units normally involved in this type of development. In most urban areas, land is expensive and distance setback alone can rarely be afforded, unless the intervening land can be used for other compatible uses as will be discussed.

6.1.2 NOISE INSENSITIVE BUFFER ZONES

Setback strips can be put to other useful application by insertion of noise insensitive buffer zones. This approach offers two advantages; firstly the setback area is not wasted and, in fact, utilized for a compatible land use. Secondly, additional shielding of the subdivision against noise is provided if the buffer zone utilization calls for fairly high and continuous structures. Typical land uses of the buffer strip are subdivision parking, parks and possibly active recreational uses. The option to reduce outdoor noise levels by creating a buffer zone is available only during the earlier planning stages.

6.1.3 ORIENTATION OF OUTDOOR RECREATIONAL AREAS

Another highly desirable and simple technique for noise control in outdoor recreational areas is the re-orientation of designated outdoor recreational areas. The backyards of dwellings are customarily used as private areas for the enjoyment of the outdoors and for recreational activities such as relaxation, conversation, etc., and the front yards for parking. In this case, the house structure itself can act as a finite barrier between the noise source and the receiver by shielding the backyard from noise. It must be emphasized that this method of noise control is primarily aimed at protection of designated outdoor areas of specific units, and not the entire subdivision. Careful consideration would be required in the design and layout of the dwelling unit and the individual lots to reflect the intent of use of the front yard area and ensure sufficient screening for privacy (for discussion on amenity and outdoor living area specifications Reference 16 may be consulted). To accomplish this, various alternatives for reorienting outdoor recreational areas has been identified, they include the use of a frontage road concept or other innovative designs.**

6.2 ACOUSTICAL BARRIERS AS A NOISE CONTROL MEASURE

An acoustical barrier is a physical feature, man made or natural, placed between the noise source and the noise sensitive area to reduce noise to acceptable levels. To be effective, the barrier must be long and continuous, encircling or surrounding the area to be protected, without holes or gaps. It must be sufficiently high to redirect or reflect noise waves away from the observer and should be placed as close as possible to either the noise source or the noise sensitive area. The barrier may

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** See Figures 5 and 6.

consist of an earth berm, a solid wall, or a combination of the two, and should be sufficiently dense to minimize direct noise transmission. Although well designed barriers are known to be fairly effective in reducing noise levels, they should be considered as a secondary measure after various other site planning measures have been considered for the site and have failed to reduce the outdoor levels to the design sound level limit. This point is extremely important in the case of subdivisions located adjacent to major arterial roads in urban areas where the utilisation of sound barriers is not preferable due to aesthetics, separation of neighbourhoods, safety, etc. Existing topographical features such as valleys or ravines at a residential site can quite often be successfully exploited to act as a natural barrier. In some cases topographical measures can be enhanced or wholly created at the site by excavation or land filling or by lowering the road level. Barrier walls, berms or a combination; usually referred to as "thin barriers" have been experimented with and are extensively used in Ontario. There are well-known advantages and disadvantages of using acoustical barriers and one should be extremely careful in selecting and designing such structures. See Figures 7,8,and 9.

Now that we have briefly discussed "thin barriers", let us discuss the other important form of acoustical shielding namely "thick barriers". In this method, buildings located in the first row perform the function of the noise barrier for the rest of the site. The buildings so utilized are called barrier blocks. Barrier block buildings located in the first row of a subdivision, such as row of townhouses or link dwellings, function as the noise barrier by reducing excess noise over a large area. This is an effective alternative to the construction of a "thin barrier".

It must be emphasized that the first row housing barrier block is not used to protect the rest of the site while exposing people living in the barrier block to excessive outdoor and indoor noise levels. Barrier blocks are generally designed to be taller; or alternatively, at higher elevations than the other dwellings to be protected and outdoor recreational areas associated with the housing barrier blocks are usually re-oriented towards the protected side away from the noise source. To put it simply housing barrier blocks, if properly designed, would indeed provide effective protection to themselves as well as to the rest of the site to be protected. See Figures 10,11,and 12.

Among the alternative noise control measures discussed under the heading of Acoustical Barriers, barrier blocks apply most widely and offer the most creative and elegant answer to the subdivision noise impact problem. Many subdivisions in Ontario have been successfully completed with the use of housing barrier blocks. The Noise Pollution Control Section encourages the use of barrier blocks as a design alternative to achieve economical and aesthetically acceptable outdoor and indoor noise control. Architects have evolved many pleasing exterior designs in response to this challenge.

6.3 ARCHITECTURAL DESIGN

These measures are mostly employed to meet indoor sound level limits, although applications to reduce outdoor levels are also possible.

6.3.1 ORIENTATION OF BALCONIES AND TERRACES

The first type of architectural design involves orientation of balconies and terraces on the shielded side of the building. This is somewhat similar to the re-orientation of backyards and patios discussed earlier, except this application involves outdoor recreational areas located at higher elevations. Shielding of outdoor areas by locating in the acoustical shadow of the building is an inexpensive measure easily adopted during the early planning stages of a particular building, and it commonly involves the use of single loaded buildings, or alternatively the use of through-units having double exposure to each side of the building. The quieter side would normally be utilized for the construction of balconies and terraces,as shown in Figure 12.

6.3.2 ROOM AND CORRIDOR ARRANGEMENT

The second architectural measure is interior room and corridor arrangement which involves re-arranging the less sensitive rooms and spaces adjacent to the exposed walls. The noise sensitive areas include bedrooms, living rooms and dens while, on the other hand, bathrooms, closets, storage rooms, corridors, stairways, etc. are typical examples of less sensitive areas to noise. With the use of good planning principles applied in the early stages of the floor plan design, the problem of noise exposure of the occupants of the home can be effectively solved at practically no added cost.

6.3.3 ORIENTATION OF WINDOWS

The third architectural measure involves orientation of windows by providing them in the walls which are not directly exposed to the noise source. This measure is somewhat complementary to room and corridor arrangements, and the effectiveness of this measure also depends on the orientation of the wall with respect to the noise source.See Figures 6 and 12.

6.3.4 BLANK WALLS

Concerning the use of blank walls as an architectural measure, the degree of success is greatly dependant on proper utilization of room and corridor arrangements and orientation of windows for lighting and ventilation. In this measure, blank walls are utilized on the building facades as well as the building sides overlooking the noise source. The blank walls find application in high density housing, stack townhouses, and also in medium density housing. It should be noted that the use of blank walls imposes two restrictions. The conventional house plan normally relies on openable windows located in opposite walls to provide lighting and ventilation. With the use of one blank wall the flexibility to provide windows is somewhat reduced and care must be taken to ensure sufficient lighting and ventilation. The other restriction is that apartment buildings with one blank wall are normally single loaded, resulting in the corridors and passageways being under-utilized. Significant reduction of noise levels indoors is possible with the use of blank walls. In Ontario several buildings have been designed with blank walls facing major noise sources (with the exception of sealed and fixed windows to provide additional lighting and improve the aesthetics). So far, the reaction to this design has been favourable among Architects, planners and developers.

6.4 CONSTRUCTION TECHNIQUES

The above discussion indicated the feasibility of achieving acceptable outdoor sound levels even though dwelling units would be located in high sound level areas. Therefore, it is expected that the indoor sound levels at such locations would be unacceptably high without the inclusion of indoor noise control measures. If indoor noise levels cannot be lowered sufficiently by the design of the architectural features, further reduction is possible by employing special construction materials and techniques. The specific measures include acoustical treatment of walls, windows, doors and roofs.

6.4.1 BUILDING COMPONENTS

The acoustical treatment of walls involves the use of a wider air-space, added thickness of insulation material as well as the use of structural block. The acoustical treatment of windows includes reducing the size of windows, increasing the glass thickness, using double glazed window with air-gap between the panes, and ultimately sealing of the standard windows in the wall. The acoustical treatment of doors involves providing a solid core door, adding a screen door and ultimately providing double doors with seals. While the conventional construction techniques and the materials normally used in roof and wall constructions usually provide adequate sound insulations it is a very well known fact that the weakest links in housing design are the windows and doors.

6.4.2 VENTILATION

Another important consideration in building design is the use of air conditioning or specially designed inert or mechanical ventilation systems. The acoustical insulation properties of windows and doors apply to well fitted, fully weather-stripped windows and then only when these windows are closed. The effectiveness of the sound insulation is considerably reduced if the windows are left open. Since, in noisy areas, the windows should remain closed for the majority of the time, the Ministry of the Environment requires that an alternate means of ventilation, either air conditioning or a specially designed ventilation system be provided. It must be emphasized, however, that the need for such provision should not be regarded as a luxury item as the success of achieving acceptable indoor sound levels inside dwelling units located in hostile noise environment areas primarily depends on adequate ventilation.

It must be remembered that the design of noise control measures in a given situation may involve the use of one or more of the outdoor and indoor measures discussed above.

7.0 PREPARATION OF PUBLICATIONS ON THE TECHNOLOGY OF NOISE CONTROL

The extensive experience gained over the years and the knowledge explosion within the Ministry was further spurred by the need to prepare publications and develop the training manuals required to train municipal noise control officers and land use planning and approving authorities. These manuals were planned, developed and written by Ministry staff, often under extreme pressure to meet planned deadlines while continuing to carry out the normal, routine work load. A succession of supplementary reports and government policies also appeared in quick order thus expanding public knowledge and noise awareness. Many internal reports were also developed on diverse topics such as the design of acoustical shrouds for air-conditioners, etc. A partial list of such publications and announcements are included in the References.

8.0 THE MINISTRY OF THE ENVIRONMENT'S EDUCATIONAL PROGRAM

Over the last four years the Noise Pollution Control Section, in reviewing over two thousand proposed land uses, has gained considerable experience in land use planning with respect to noise. The experience has revealed the need to:

1. Disseminate widely the criteria and prediction methods adopted by the Ministry, as well as the design and planning expertise acquired.

2. Establish a uniform approach to assessment by those concerned with the formulation of plans and housing design particularly in the earlier stages of planning and development.

3. Streamline the review process.

4. Develop improved procedures and technology.

8.1 ACOUSTICS TECHNOLOGY TRAINING COURSES

It is towards meeting these needs and fulfilling the Ministry's objectives that the latest addition to Environment Ontario's training courses has been prepared. It is designed to assist those concerned with land use planning and the provision of an acceptable noise environment in new developments. From the beginning, the Land Use Planning Course (Reference 11) was designed with the following objectives in mind:

1. Reach those concerned in the planning, design and review of land use and residential developments irrespective of technical background. The training program is aimed at a wide spectrum of interested groups including planners in private and municipal government sectors, Architects, consultants, developers and Ministry of the Environment regional personnel.

2. Enable a planner to "red flag" proposals because of potential noise impacts. This initial "sorting" speeds up the review of initial proposals for development by recognising those projects which are, or are not, subject to serious noise impact.

3. Make planners aware of the common pitfalls and instill in them useful rules-of-thumb in the hope that initial proposals they process are much more soundly formulated.

4. Demonstrate, illustrate and evaluate the various noise control measures available along with their most efficient use in time and space.

5. Provide practical training in workshops, field measurement and study of actual case histories.

6. Provide an explanation of the legislation.

As far as we are aware, the Ontario Acoustics training program is the most comprehensive offered in North America by any level of government. More than 1,000 trainee-weeks of instruction and training has been provided since 1975.

The educational program of the Ministry also includes a well planned series of short seminars held throughout six regions in the Province of Ontario. Seminars are organized in the major centres and are usually well attended by many interested groups who prefer to attend local two-day seminars instead of the one-week training course offered in Toronto. Information on the courses may be obtained by contacting the Training and Certification Section of the Ontario Ministry of the Environment in Toronto. (Reference 20).

9.0 REVIEW AND ENFORCEMENT PROCEDURES

The discussion under this heading is very much related to the earlier discussion on the study of legislative powers available to control noise. The following simplified procedures may prove to be valuable in administering a similar program.

9.1 SUBMISSION GUIDELINES

It has been found in Ontario that much time can be spent gathering enough data to evaluate the noise impact on new developments. This data gathering can be considerably reduced by asking the proponent to perform the task. With this in mind, approval submission guidelines were prepared in order to inform development proponents, Architects, consultants and contractors what data must be provided (Reference 1). Typically, train or traffic data, industrial noise source description, distances, speeds and topographical information would be required. An organized inventory of major noise sources in a given urban area may prove to be useful in evaluating new submissions adjacent to such potential sources of noise. (See Reference 1).

9.2 INITIAL COMMENTS

In the early stages of investigating a new land use proposal with respect to noise, it is only necessary to establish noise levels for the site and compare these with the objective sound levels. This will quickly indicate whether noise will be a problem or not. If it is then the extent of the problem will also be known. At such an early stage it would probably not be necessary to investigate detailed noise control measures. It is very important that these initial comments be handled promptly and efficiently to avoid holding up projects with no potential noise problem.

9.3 PREDICTION TECHNIQUES

For suface transportation noise sources, prediction techniques are available which provide reasonably accurate prediction of sound levels provided that reliable input data is used. Wherever possible, approvals staff should have such prediction methods programmed on computers or programmable calculators to enable them to perform rapid and mistake-free sound level prediction calculations.

9.4 INVESTIGATION AND APPROVAL OF NOISE CONTROL MEASURES

The task of designing acceptable noise control measures for specific sites must be left to the developer and/or consultant who is considerably assisted by documents and references made available by the approving agency. Discussions may well have to be arranged between the approving authority, the developer, consultant and also the municipality with whom the developer may finally have to enter into a written agreement to institute the agreed upon noise control measures.

9.5 AUDIT OF THE NOISE CONTROL PROGRAM'S EFFECTIVENESS

The main objective of an audit program is to check the effectiveness of a noise control program by observing past activities, monitoring the results, and comparing the two. The audit program should address technical and non-technical matters related to the work program. The work areas to be covered by the program are diversified and may include land use assessment projects, environmental assessment projects, development of guidelines, policy proposals, the development of technical procedures for use by others, training courses and seminars, and special projects. The major components of an audit program include:

1. Investigating the effectiveness of noise control measures and policies.**

2. Investigating the accuracy of the prediction models and procedures normally used in evaluating and commenting on land use plans. This may involve physical measurements in the field as well as comparing the field results with those predicted. The field investigation deals with a representative sample of actual developments as built, covering a wide spectrum of noise sources and development types. The criteria for checking the effectiveness of the program includes:

    a. Did the development meet the specified indoor and outdoor sound level objectives?

**NOTE: The role of the Pollution Control Branch of the Ontario Ministry of the Environment inter alia is to monitor and audit the effectivness of the noise control program, abatement strategies and policy. Reference 21.

b. Are there deficiencies on the part of the enforcement agencies and/or the developer in implementing the planned noise control measures?

3. Documentation of the general response of the end users (occupants of developments where noise control measures have been incorporated upon the advice of the approving agency) to the existing sound environment. This may involve some interviewing of the occupants of completed projects as part of the field measurements program.

10.0 CONCLUDING REMARKS

The elimination, or control of the source of pollution is the primary objective of the environmental manager. There are, however, limits to what is practical and technologically possible. This applies to all types of pollution but it is particularly applicable to noise, especially noise from transportation. Because of the limits to practicality and technology, planners have a share in the responsibility for providing an acceptable level of environmental quality. The planning process being the legal and administrative mechanism for integrating environmental concerns, such as noise, with land use.

REFERENCES

1. Ontario Ministry of the Environment, "Model Municipal Noise Control By-Law, Final Report", August 1978, Ontario Government Bookstore, Toronto, Ontario.

2. Harmelink, M.D., "Noise and Vibration Control for Transportation Systems", Ontario Ministry of Transportation and Communications, Report No. RR168, October 1970, Toronto, Ontario.

3. Harmelink, M.D., and Hajek, J.J., "Noise Barrier Evaluation and Alternatives for Highway Noise Control", Ontario Ministry of Transportation and Communications, Report No. RR180, September 1972.

4. The Government of Ontario, The Planning Act, Revised Statutes of Ontario, 1970.

5. The Government of Ontario, The Environmental Protection Act, 1971.

6. City of Mississauga Planning Department, The Official Plan of the City of Mississauga Subsidiary Planning Area, Draft, July 1978, Mississauga, Ontario.

7. City of Brampton, City of Brampton Draft Official Plan, September 1978, Brampton, Ontario.

8. The Government of Ontario, The Environmental Assessment Act, 1975, Chapter 69, April 1976.

9. Ontario Ministry of Housing, "Guidelines on Noise and New Residential Development Adjacent to Freeways," April 1979, Local Planning Policy Branch, Ministry of Housing, Toronto, Ontario.

10. Ontario Ministry of Housing, "Land Use Policy Near Airports - Based on the Noise Exposure Forecast (NEF) System," March 1978, Local Planning Policy Branch, Ministry of Housing, Toronto, Ontario.

11. Ontario Ministry of the Environment, "Acoustics Technology in Land Use Planning, Volume 1 Analysis of Noise Impact, July 1977." Ontario Government Bookstore, Toronto, Ontario.

12. Central Mortgage and Housing Corporation, Ottawa "Road and Rail Noise: Effects on Housing", Publication No. NHA5156 12/77, Ottawa, Ontario.

13. Central Mortgage and Housing Corporation, Ottawa "New Housing and Airport Noise", Publication No. NHA5059 11/76, Ottawa, Ontario.

14. Owen R. Scott and Associates Limited, North-North Dixie Community, Streetsgate, Noise Attenuation Report, June 1978, submitted to the City of Mississauga, Ontario.

15. City of Mississauga, Creditview District Noise Study, May 1977. Ontario.

16. Town of Vaughan, Amendment No. 70 to the Official Plan to the Town of Vaughan Planning Area, Thornhill - Vaughan Community Plan, Noise Studies 1977, Ontario.

17. Schultz, T.J., "Noise Assessment Guidelines, Technical Background", prepared for U.S. Department of Housing and Urban Developments, HUD Report No. TE/NA172, Washington, D.C.

18. Gidamy H., Hemingway J., "Setting and Refining Sound Level Limits for New Residential Development", presented at the Canadian Acoustical Association Annual Meeting in Ottawa, October 1977.

19. Central Mortgage and Housing Corporation, Ottawa "Site Planning Criteria," Application No. NHA5143 9/77, Ottawa, Ontario.

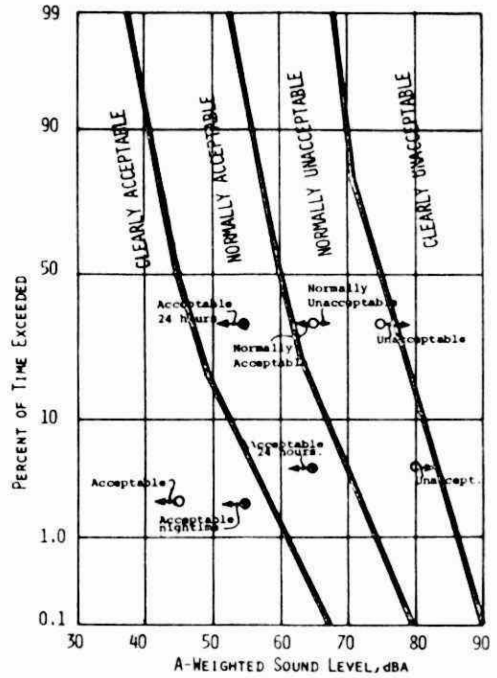
20. Ontario Ministry of the Environment, "Information on Training Courses and Seminars" Annual, Toronto.

21. Ontario Ministry of the Environment, "Audit of Abatement Strategies,Plans and Procedures, 1975 - 1978." Annual, Toronto.

22. Ontario Ministry of Housing,"The Planning Act, A Draft for Public Comment, December 1979,"Toronto.

1. Legislative Power
2. The Planning Process at Various Levels of Government
3. Sound level Objectives
4. Identification of Feasible Noise Control Measures
5. Preparation of Publications - Technical and Administrative Procedures
6. Educational Program
7. Establish Review and Enforcement Procedures
8. Audit of Program Effectiveness

Figure 1 : Components of a Land Use Planning Program to Control Noise.



○ HUD External noise exposure (HUD Circular 1390.2) for new construction sites, 8/4/1971.

● HUD Internal noise exposure (HUD Circular 1390.2) for new and rehabilitated residential construction, 8/4/1971. Values shown in this figure are 10 dBA higher than those shown in HUD Circular 1390.2, i.e. the indoor levels are converted to outdoor levels assuming typical open window attenuation.

Figure 2: Cumulative A-weighted level distributions that closely approximates the actual levels in HUD's interim policy for non-aircraft noise measured outdoors in residential areas.

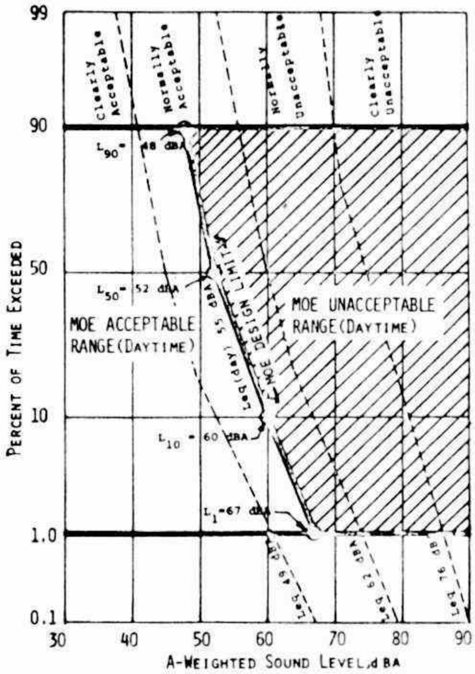
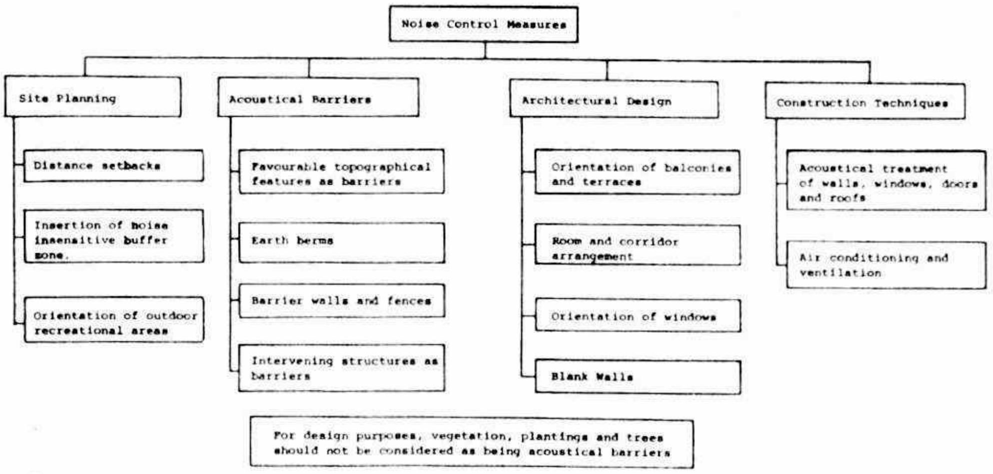


Figure 3: Ministry of the Environment (MOE), Ontario, original "Design Cumulative A-Weighted Sound Level Distribution" superimposed on the Ranges suggested for U.S. HUD.


Noise Control Measures
Site Planning
Distance setbacks
Insertion of noise insensitive buffer zone.
Orientation of outdoor recreational areas
Acoustical Barriers
Favourable topographical features as barriers
Earth berms
Barrier walls and fences
Intervening structures as barriers
Architectural Design
Orientation of balconies and terraces
Room and corridor arrangement
Orientation of windows
Blank Walls
Construction Techniques
Acoustical treatment of walls, windows, doors and roofs
Air conditioning and ventilation

For design purposes, vegetation, plantings and trees should not be considered as being acoustical barriers

Figure 4 : Summary of Noise Control Measures Applicable to Design of New Housing

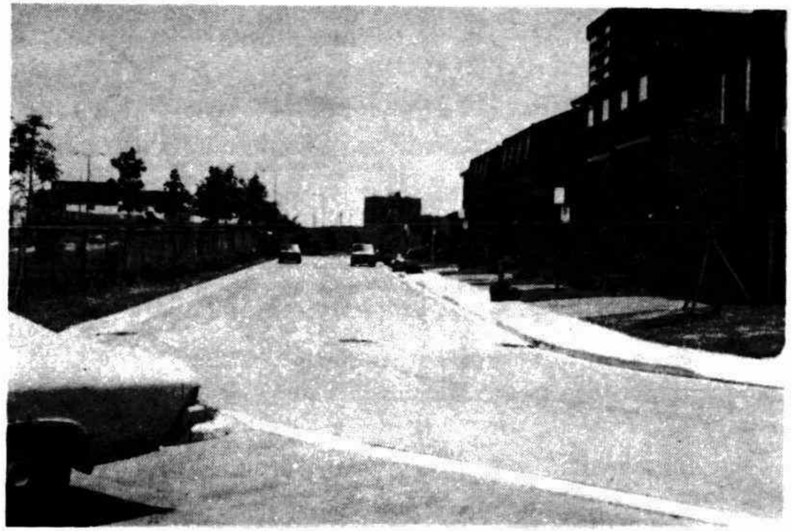


Figure 5: Re-orientation of Outdoor Recreational Areas to Shielded Side of Building Using the Frontage Road Concept.

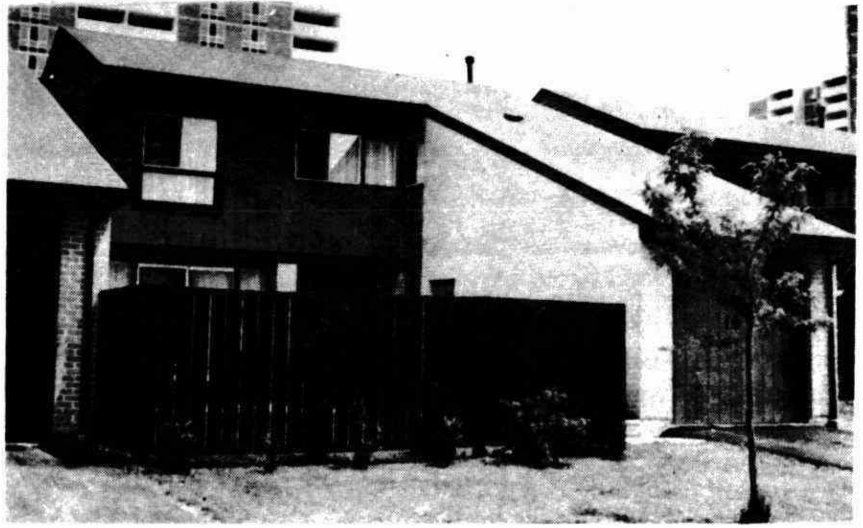


Figure 6: Re-orientation of Outdoor Recreational Areas to Shielded Side of Dwelling Units Using Innovative Design.

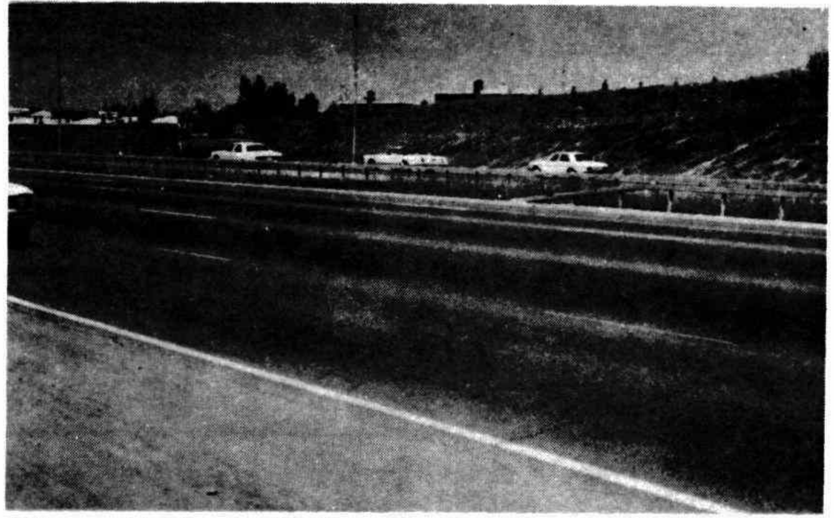


Figure 7: An Earth Berm Protecting Dwelling Units from Freeway Noise.

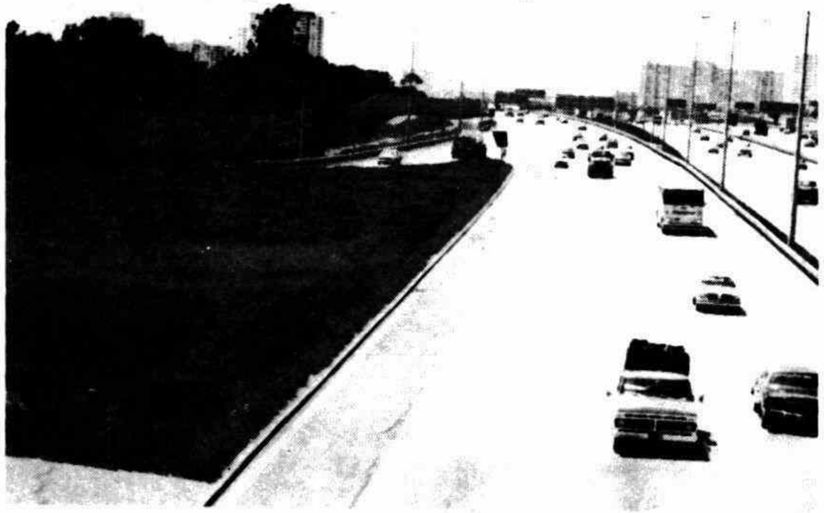


Figure 8: A Barrier Wall Designed to Protect Adjacent Residential Subdivisions.

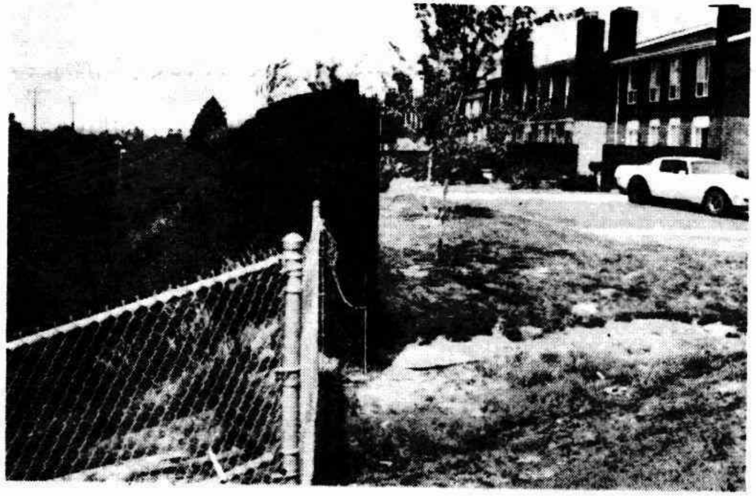


Figure 9: A Combination,Earth Berm/Barrier Wall Designed to Protect Outdoor Recreational Areas of a Residential Subdivision.

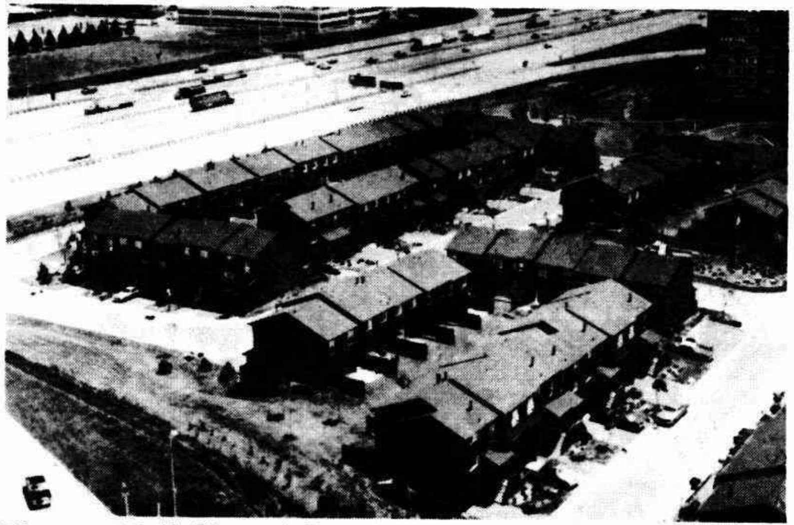


Figure 10:U-Shaped Barrier Block Housing Employed to Protect Itself and Protect Other Units on a Site Adjacent to a Major Freeway.

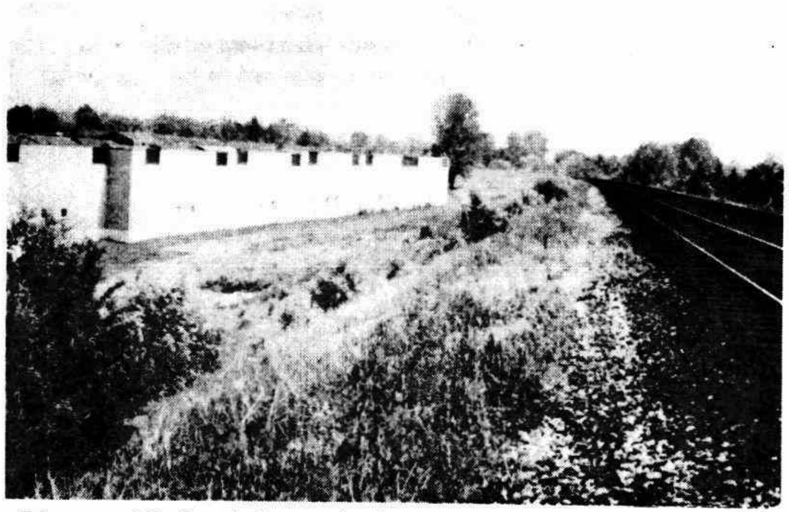


Figure 11:Semi-Detached Dwelling Units Employed as a Barrier Block Adjacent to Elevated Railway Tracks.

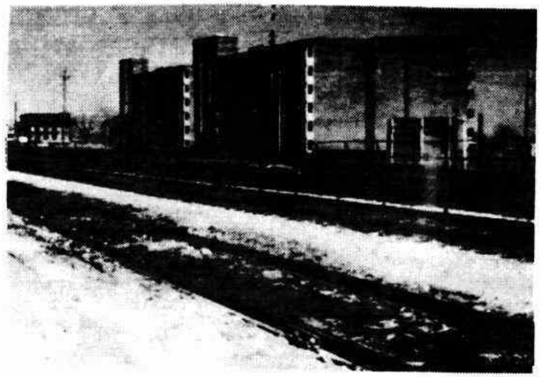


Figure 12:A Seven-Storey Barrier Block Residential Building Adjacent to Elevated Railway Tracks(all oudoor and indoor uses are protected by the blank side).

Table 1: interim L_N and Leq Sound Level Limits Derived from U.S. HUD (Outdoor).

L_N	Limit (dBA)
L_{90}	48
L_{50}	52
L_{10}	60
L_1	67
L_{eq}	55

Table 2: Indoor Sound Level Limits.

Type	Equivalent Sound Level (L_{eq}), dBA
Bedrooms, sleeping quarters, hospitals, etc. (Time period 23:00 - 07:00)	40
Living rooms, hotels, motels, etc. (Time period 07:00 - 23:00)	45
Individual or semi-private offices, small conference rooms, reading rooms, class-rooms etc. (Time period 07:00 - 23:00)	45
General offices, reception areas, retail shops, etc. (Time period 07:00 - 23:00)	50

Table 3: Sound Level Limits for Outdoor Recreational Areas (07:00 - 23:00)

Sound Descriptor for the Entire Period	Sound Level Limit, dBA
L_{50}	52
L_{eq}	55

Table 4: Sound Level Limits for Outdoor Areas (23:00 - 07:00)

Sound Descriptor for the Entire Period	Sound Level Limit, dBA
L_{50}	47
L_{eq}	50

Table 5: Applying Recommended Sound Level Limits to Residential Land Use Developments.

Excess Above Recommended Sound Level Limits. dBA	Change in Subjective Loudness Above.	Magnitude of the Noise Problem.	Noise Control Measures (or action taken)
No excess.	-	No expected noise problem.	None.
1 to 5 inclusive.	Noticeably louder.	Slight noise problem.	Optional (if no physical measures are taken then prospective purchasers or tenants should be made aware by a clause in the deed or rental agreement).
6 to 10 inclusive.	Almost twice as loud.	Definite noise problem.	Recommended.
11 to 15 inclusive.	Almost three times louder.	Serious Noise problem.	Strongly recommended.
16 and over.	Almost four times louder.	Very serious noise problem.	Strongly recommended (may be mandatory).

Fischer-University-Hallman Corridor Noise Impact Assessment

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This paper was originally presented at the 1979 RTAC Meeting in Regina, Saskatchewan.

ABSTRACT

In 1975, the recently formed Regional Municipality of Waterloo met with strong opposition, from local residents, to the proposed extension of an arterial roadway in the rapidly developing west sides of Kitchener/Waterloo. Among other items, the major concern of the local residents abutting the future 4-lane road was the effects of traffic generated noise on the existing residential environment.

As part of the preliminary design study for the new road, a pilot study to assess noise impact was carried out by the consultants, which ultimately recommended the construction of noise attenuating earth berms along a portion of the corridor. The noise study was based on the L_{10} model which calculates the noise level which would be exceeded 10 per cent of the time, but since that time, the more popular base to assess traffic generated noise levels has been the Leq model (Equivalent Energy Continuous Level), which in fact, is the standard form recommended by the Ministry of the Environment of Ontario.

Recognizing that there are probable differences between the L_{10} and Leq models, this paper provides a reassessment of future traffic noise for a section of the Fischer-University-Hallman Corridor, comparing predicted levels for the original design criteria with no berms to the predicted levels for the recommended, or approved, design criteria with earth berms.

To provide noise attenuation along the designated corridor section, capital expenditures are estimated to be a significant percentage of the original project cost. The basis for these added costs and their relationship to the original and final project criteria are outlined in detail.

The Fischer-University-Hallman Corridor has now been approved for construction over a period of about five years, including the noise attenuating earth berms in the area of the Victoria Hills subdivision. However, the decision process was not an easy one, and in the final analysis, traditional roadway engineering design may have been altered for many years to come.

FISCHER-UNIVERSITY-HALLMAN CORRIDOR

NOISE IMPACT ASSESSMENT

INTRODUCTION

The Cities of Kitchener and Waterloo have benefited immensely since completion of the Conestoga Parkway in 1970. The controlled access expressway has provided relief from traffic congestion in the south and east ends of the Twin Cities, while providing a direct connection to arterial routes on the west side of Kitchener/Waterloo.

The absence of a major arterial roadway circumventing and connecting the west side of Kitchener/Waterloo however, combined with the rapid urban growth in this sector of the Twin Cities, has created traffic congestion problems on existing arterial and collector routes. The need for completion of a major arterial roadway to serve adjacent developments was identified.

In 1975, the Regional Municipality of Waterloo[1] initiated a preliminary design study for the Fischer-University-Hallman Corridor. When completed, the proposed 7.3 miles of designated arterial roadway would not only provide an alternative to existing parallel routes which serve the west side, but would also take on added significance because of its interchange connection with the Conestoga Parkway (Highway 7) and resultant uninterrupted access to Highways 8 and 401, as shown on Plate 1.

The Fischer-University-Hallman Corridor is comprised of sections of both existing and proposed roadways, although most of the proposed sections are designated as a future right-of-way on Registered Plans of abutting subdivisions. In essence, planning of the "future" roadway dates back several years to the Waterloo County Planning Board, and municipal officials have made a conscientious effort to inform the public of its existence through Official Plans and Registered Plans.

Despite the degree of preplanning and public awareness, the inevitable controversy generated by public information meetings on the project resulted in a political decision to postpone the project until environmental concerns raised by the local residents were satisfied.

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[1] *The Regional Municipality of Waterloo was formed on January 1, 1973 and is composed of seven (7) local municipalities: the Cities of Kitchener, Waterloo, and Cambridge (formerly Preston, Hespeler, and Galt), and the Townships of North Dumfries, Wellesly, Wilmot, and Woolwich.*

A section of Fischer Road, from the Henry Sturm Greenway to Glasgow Street, was selected as the project limits for an examination of the impacts of traffic generated noise on existing dwellings in the Victoria Hills subdivision. It was anticipated that the Noise Impact Assessment would pave the way to a Policy Statement on noise attenuation measures on Regional Roads, stemming from factors such as implementation costs for attenuation measures, effects on established geometric design criteria caused by physical attenuation measures, the degree of noise reduction achievable from certain barrier designs, maintenance cost implications, and the possibility of establishing an expensive precedent for future projects.

The resultant published Noise Abatement Study, incorporated within the Fischer-University-Hallman Corridor Preliminary Design Report, was carried out by J.S. Keeler Limited in association with M.M. Dillon Limited, Consulting Engineers. The report examines the beneficial effects of protective earth berms parallel to the proposed roadway in conjunction with additional geometric alterations.

Calculations of predicted noise levels within the Noise Abatement Study were based on a mathematical model of traffic noise generation and propogation predicting L_{10}, which is the noise level exceeded 10 per cent of the time. The 'A' weighted scale was used.

In the final analysis, the above report predicted that noise levels would be significantly reduced by the proposed attenuation measures (earth berms) and recommended their implementation.

Currently, the Ministry of Environment of the Province of Ontario recommends that traffic noise predictions be based on the Leq (Equivalent Energy Continuous Level) model. Recognizing that there are inherent differences in the L_{10} and Leq parameters, and their results, the evolution of the Fischer Road design from the initial and final proposals are herein retraced, describing the effects of the protective measures, all using the Leq model.

The length of roadway for which the Noise Impact Assessment is reviewed totals only 3,400 lineal feet of the entire corridor, with earth berm construction recommended for one side over a distance of 3,000 lineal feet. However, the effects of this study and its future implications are proven to be significant to the total project costs.

ROAD GEOMETRICS

When completed, Fischer Road will be a 4-lane facility with northbound and southbound lanes divided by a 17-foot sodded median, all within a 150-foot right-of-way. To accommodate lower traffic volumes, only the ultimate northbound lanes are to be constructed initially. The first stage is to be operative in 1981, while completion of the ultimate four lanes is scheduled for 1991.

In an effort to reduce capital construction costs, the original design criteria provided for a rural cross section, with no storm drains, catch basins, or curb and gutter. Also, no consideration was given to special measures to mitigate traffic noise propogation.

Subsequently, as a result of Municipal Council resolutions, a number of changes were made to the original design:

(i) Final design was to provide for the largest possible earth berms along the east edge of the road allowance, with the restrictions that berms must not encroach on private property and adequate boulevard space is retained, between roadway and toe of berm, for utility requirements.

(ii) The road cross section was altered from a rural to an urban design to allow for more sizeable earth berms. By eliminating gravel shoulders and roadside drainage ditches, and installing curb and gutter and storm drains, the toe of berm could be advanced closer to the edge of the travelled roadway.

(iii) The roadway was shifted, within the available right-of-way, up to 10 feet westerly and away from the existing homes in the Victoria Hills subdivision. Again, this measure was to allow for increased height of berm.

(iv) The road profile was substantially lowered (up to 7.5 feet maximum) from the Henry Sturm Greenway to the CNR Overpass.

(v) An intersecting street (Hazelglen Drive) was closed at Fischer Road to allow for a continuous berm at a critical location where houses were very close to the future roadway.

A typical road cross section (station 135+00), showing the original design criteria and the comparative modified designs, is illustrated on Plate 2. In addition, longitudinal profiles of noise source (original and recommended), top of berm, and noise receiver, are illustrated on Plate 3.

In constructing the largest possible earth berm, an average height of 6 feet of fill was added to the original grades along the centre line of berm. The range of berm heights was from zero feet to 11'-0. The effect of lowering and shifting the roadway, combined with an urban standard cross section, was to provide a net increase of top of berm above edge of pavement averaging 7'-0. The range of difference provided from the original to the recommended design was from a minimum of 3'-0 increase to a maximum of 10.5 feet.

Not all of the above design changes were implemented simultaneously, although one change may have logically prompted another. Assessment of noise levels, in the following sections, is based on the premise that all of the above changes are implemented together.

NOISE IMPACT ASSESSMENT

Existing Noise Environment

During the month of May, 1979, representative noise levels were measured at a number of locations at the rear of existing properties which abut the future road right-of-way. Each measurement was taken over a 1-hour period, in the early afternoon, using a Metrosonic dB-611 Sound Energy Analyser, which computes Leq values automatically.

Table 1 lists the results of the existing Leq noise levels, which range from a low of 43 dBA to a high of 51 dBA. During the course of measurements, instantaneous sound levels ranged from 40 to 54 dBA. These noise levels are typical of a suburban environment with no intrusive traffic noise.

TABLE 1: EXISTING NOISE LEVELS

Location	Leq (1) [dBA]
near 119-121 Ingleside	46
near 327 Hazelglen	50 (2)
near 122-124 Shadeland	47
near 96-94 Shadeland	51 (2)
near 367 Westwood	47
near 29 Westwood	43

NOTES:

(1) All measurements were taken under sunny skies with little wind. No noise sources unusual to the locations studied were in evidence.

(2) These measurements were taken at a time when numerous children were playing nearby and a number of dogs were barking. There were, as well, a couple of motorcycle trail bikes in the area for a short time, and a passenger train passed by on the nearby CNR line.

Traffic Parameters

The parameters listed in Table 2 were used in the noise prediction phase of this study. Traffic volume is taken from the Region of Waterloo Transportation Plan Review 1978.

TABLE 2

TRAFFIC PARAMETERS
(for the year 1991)

ITEM	VALUE
Number of Lanes	4
AADT	29,300
% Trucks	10
Speed (MPH)	35
Source Height above Edge of Pavement	10 feet

The year 1991 was chosen as the prediction year because given an opening date of 1981 for this roadway, 1991 provides a 10-year horizon period. The next section in this chapter will compute the 1991 noise levels as well as comparing these to forecast 1981 and 2001 noise levels.

Predicted Noise Levels

The future noise levels were predicted using the Leq equation as advocated by both MOE (Ministry of Environment)[1] and MTC (Ministry of Transportation and Communications)[2] of the Province of Ontario.

Both the original (rural standard) and recommended design geometrics were considered in calculating the future noise levels. The predicted noise levels for the above cases are listed in Table 3 for various residential units. The noise levels that would occur given the original design are in the range of 60-65 dBA, while the predicted noise levels based on the recommended design criteria range from a low of 51 dBA to a high of 64 dBA.

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1) *Acoustics Technology in Land Use Planning - Volume 1 Analysis of Noise Impact, July 1977.*

2) *Ontario Highway Noise Prediction Method, Ministry of Transportation and Communications, January 1975 RR197.*

The Ministry of the Environment currently suggests that designers should strive to achieve a maximum noise level at outdoor, rear yard, recreational areas equal to Leq = 55 dBA. If this level is not attainable using conventional design criteria, an upward range of 5 dBA, to a maximum level of Leq = 60 dBA, is permitted before physical noise attenuation measures are demanded.

To graphically illustrate the effect of the implemented geometric design changes on predicted noise levels, the Leq = 60 dBA contour lines are shown on Plate 4.

TABLE 3: PREDICTED TRAFFIC NOISE LEVELS (1991)
(refer to Plate 4 for dwelling locations)

Location: (Outdoor, Rear Yard, Recreation Areas)	Noise Level, Leq in dBA Original Design Proposal	Recommended Design Proposal
14/16 Ingleside Place	61	52
79/81 Ingleside Drive	61	51
99/101 Ingleside Drive	62	52
109/111 Ingleside Drive	62	54
123/125 Ingleside Drive	61	61
127/129 Ingleside Drive	60	59
327 Hazelglen	65	64
122/124 Shadeland Crescent	62	55
102/104 Shadeland Crescent	61	55
365 Westwood Drive	60	60
423 Westwood Drive (Unit 29)	61	61

For simplicity of calculation, traffic volumes were assumed to be concentrated on the edge of pavement nearest the dwelling units. It is therefore a worst case prediction. Normal traffic patterns within the Region show a directional split of traffic in the 60/40 range. If the traffic was split this way with only 40 per cent of the volume on the northbound lanes (nearest the dwelling units) and 60 per cent on the southbound, the resultant unattenuated noise levels would be in the order of 1 - 1.5 dBA less than predicted. This difference though, is offset by the fact that the further the noise source is away from the noise barrier the less the attenuation will be.

If the year 1981 and 2001 noise predictions are compared to the 1991 levels it would be seen that the 1981 levels would be about 4 dBA less than those in 1991, while the 2001 levels would be only approximately 1 dBA more than those in 1991. The year 1991 can therefore be seen as a logical base to predict noise levels as it would account for the major growth period of volume on this roadway.

IMPLEMENTATION AND RELATED COSTS

Although numerous forms of noise abatement measures are available to the designer, it became obvious that earth berms were most appropriate for the Fischer Road project. The surplus earth cut, which was increased with the road profile lowering, could be utilized in forming the berms while saving somewhat on the off-site disposal costs. Also, it was felt that landscaped earth berms would be more aesthetically pleasing and psychologically acceptable than other types of barriers.

The cost of constructing an earth berm is directly related to berm height, availability of material, availability of right-of-way, the degree of landscaping applied to berms, the degree of additional works to provide for drainage, and the degree of additional works required as a result of design changes, all of which are discussed in the following paragraphs. All cost estimates are based on a completed 2-lane roadway within a full graded right-of-way.

Berm Height and Availability of Material

As can be expected, the cost of berm construction increases as the height of a berm is increased, and a significant related factor is the availability of on-site versus imported material to form a berm.

Assuming constant roadside and protected side berm slopes (2:1 and 1.5:1 respectively, for Fischer Road), the volume of material required to form a berm increases in relation to the square of the berm height. Furthermore, imported fill material may be two to four times as costly as locally acquired materials from roadway construction.

Thus, depending upon berm height and availability of material, construction costs for noise protective earth berms may be considered economically viable or quite prohibitive in relation to other project costs. The following Table 4 gives an indication of estimated berm construction costs (one side of road, including landscaping).

TABLE 4

BERM CONSTRUCTION COSTS (Per Lineal Foot)

Berm Height	6 Feet	8 Feet	10 Feet
Berm Utilizing native on-site material	$10-11.00	$15-16.00	$19-21.00
Berms Utilizing imported fill material	$16-18.00	$25-28.00	$34-38.00

The average height of berm to be constructed on Fischer Road is six (6) feet, utilizing surplus native materials. Excluding Engineering, the total estimated cost increase on the project for berm formation is then (3,000 feet @ $10.50/foot) $31,500.

Availability of Right-of-way

Assuming that noise attenuation berms are to be confined within the road right-of-way, and considering that for every 10 feet of height, approximately 35 feet of right-of-way is consumed, allocation of space for noise attenuation berms within a restricted right-of-way becomes a major consideration.

Accentuating the problem of right-of-way availability is the provision for utility services. It is appropriate to assume that most utilities cannot be effectively located on the side slopes of a berm, and most utility authorities avoid installations under travelled roadway. Add to this the fact that utilities within a major corridor are trunk facilities, and the result is serious congestion of the remaining areas of road right-of-way.

Thus, to accommodate roadway, utilities, and earth berms of any significant height, a conventional 100-foot or 120-foot right-of-way will normally prove inadequate for a 4-lane arterial.

Consideration may be given to placing noise abatement features outside of the roadway right-of-way. However, if this requires acquisition of property, then this could be a highly significant cost item.

The original design criteria of a rural standard for Fischer Road was modified to an urban design because of problems with right-of-way availability. Even with a 150-foot right-of-way, it was not physically possible to provide road shoulders and drainage ditches as well as effective noise attenuation berms. To add additional berm height, modifications were taken one step further by shifting the roadway up to 10 feet, within the right-of-way, away from existing dwellings.

The advantages gained by the above modifications are illustrated on Plate 2.

The changes in design criteria to an urban standard added significant costs to the Fischer Road project, which may be offset slightly by reduced annual maintenance costs (excluding berms). For the initial 2-lane facility, storm drainage and curbs, less reduced ditch excavations and gravel shoulders, is estimated to add $15-20.00 per foot towards road construction costs. For the length of roadway affected, the net capital increase in cost amounts to an estimated $57,800.

Landscaping

The increased costs attributable to berm landscaping are relatively minor, although increases in expenditure may result with tree and shrub plantings on the sideslopes.

Drainage

Traditionally, natural overland drainage is unimpeded across the road right-of-way, utilizing ditches, storm drains, or combinations of methods. Earth berms installed along the edge of a right-of-way become physical barriers to natural drainage and must be considered by the designer.

For example, backlotted residential properties may require the installation of rear yard catch basins, pipe culverts, and provision of swales and open ditches to affect positive drainage, all of which add to the original cost of the roadworks.

For the most part, additional major expenditures were not required for drainage treatment on the Fischer Road corridor. In fact, with most dwellings being lower in grade than the road right-of-way, the earth berms actually intercepted a portion of the run-off to those lots and should reduce some existing drainage problems along the route. This may not be the case on other similar projects and must be considered when calculating overall cost assessment for noise attenuation measures.

For the few areas affected by additional drainage works due to berm construction, an additional cost of $15,000 is estimated for this project.

Additional Works

Design changes resulting from berm construction may result in an increased capital expenditure and increased annual maintenance costs, which is the case on this project.

The decision to lower the road profile in specific areas of the Fischer Road corridor was to assist in source/receiver separation and resulted in significant added costs. The original road profile, with a rural cross section and no berm construction, required disposal of an estimated 28,400 cubic yards of material off site. By instituting a lowered road profile and despite the construction of earth berms, the estimated surplus volume increased to 54,300 cubic yards. Combining the increased earth grading and off-site disposal costs, the net increased expenditure for profile adjustment is approximately $45,000, or $13.25 per foot.

Although a lowered profile added significantly to the cost of road construction, it was a necessary expense to complement the berm construction and make it as effective as possible as a noise barrier. Without the lowered road profile, model calculations suggest that a majority of the berm length would not be effective in reducing noise levels at existing residences.

Earth berms require on-going maintenance such as grass cutting, weed control, and erosion repair. These costs are higher than for standard roadways, but can be reduced somewhat by selecting appropriate ground covers and use of shrubs.

In areas where blown snow accumulation is experienced, roadside earth berms, combined with depressed roadways, will accentuate snow deposition and result in increased winter hazards and snow removal costs. The magnitude of these increased maintenance expenditures was not considered by the Regional Municipality in evaluating the merits of earth berm construction and are also excluded from this study.

Cost Estimate Summary

In providing approximately 3,000 lineal feet of earth berm spanning approximately 50 residences, an estimated additional expenditure of $165,000 is required for berm construction, road profile lowering, modification to urban standards, and drainage provisions. In terms of units of cost, this expenditure is $55.00 per foot, $3,300 per affected residence, or a 35-45% increase over the estimated initial 2-lane road construction costs. The previous cost estimates are summarized on Table 5.

TABLE 5

Increased Costs for Noise Attenuation on Fischer Road

(1979 Dollars)

Item	Cost Per Foot	Total Cost
Berm Construction (3,000 feet)	$10.50	$31,500
Urban Standards vs. Rural Standards	$15-20.00	$57,800
Drainage (3,000 feet)	$5.00	$15,000
Profile Adjustment (3,400 feet)	$13.25	$45,000
Subtotals	$43.75-$48.75	$149,300
Engineering and Contingencies	$5.25	$15,700
Total	$49.00-$54.00	$165,000

DISCUSSION

At the outset, the design of the Fischer-University-Hallman corridor represented a typical engineering assignment implementing traditional engineering design criteria within a defined scope of activities. Very early in the study, the municipality recognized a need for some form of environmental review and over the course of the project, organized public concern reinforced this viewpoint to the extent that the overall direction of the study was changed such that the design constraints were enlarged to include the traffic noise impact on an adjacent residential community, a feature which had not been considered in the past. This entailed the commissioning of a noise impact assessment to detail a recommended noise attenuation scheme and its associated costs.

The elements contributing to the increased cost of constructing the recommended noise berm and associated works have been shown to amount to approximately $165,000 or $3,300 per affected residential unit. Hidden costs, such as the many hours of time spent to provide the increased level of public input as well as the costs specific to the fact that this was the first "full blown" noise sensitive design prepared for the Region, have not been estimated. These untallied costs may logically be assumed to be significant, considering the "pilot" nature of the study.

Over the course of the preliminary design, it had been suggested that the $3,300 per residential unit, or lower sum, may be better spent on physical improvements to the dwellings, perhaps in the form of new double sealed windows and/or air conditioning installations. This consideration may be applicable in other situations, but it was felt that such action would not resolve the "noise" increase in the rear yard, recreational areas, in this study. Furthermore, recommended Ministry guidelines would be exceeded in many cases.

It is important to recognize that the costs associated with berm construction for a similar situation may well be quite different. With about one-third of the dollars associated with the modifications to urban from rural standards, an unbalanced picture of noise related costs is perhaps outlined. Many municipalities will select urban criteria from the beginning which places a whole new light on the subject of cost implications.

The tradeoff in this case between costs and noise attenuation can be seen from the predicted noise levels. The recommended noise berms should substantially reduce the noise levels for a majority of the affected dwelling units while for others, it will serve more as a psychological barrier than a noise attenuator.

It has been recommended that post 1981 noise levels be monitored to determine the increase in receiver noise levels relative to traffic volume growth. These investigations would be valuable in ascertaining the accuracy of the model calculations, and would also justify the possible implementation of additional measures, such as barriers atop the berms, to further reduce noise levels in areas where the earth berms did not effectively reduce levels below the Leq = 60 dBA guideline.

The political decision to approve this noise berm and accept the additional costs did not come easy. Two motions before the Regional Council to approve the Noise Abatement Measures were lost before approval of the scheme was finally obtained. The most common argument against approval was the precedent setting nature of this design inasmuch as the Region has under its jurisdiction, most of the major traffic noise generating arteries.

The most permanent feature of this project was the institution of noise control as a standard evaluation factor for all road designs now carried out within the Region. This not only includes a theoretical approach, as performed for the Fischer Road project, but has also gone to the point of informing potentially affected residents (especially in developing areas) by rough grading major roadways sometimes long before they are required to be paved. Also, under the subdivision approval process, noise evaluation is carried out as a standard procedure with the result that noise warning clauses, physical attenuation features, or even subdivision redesigns are incorporated within the Regional conditions of Draft Approval. It is expected that this prior commitment to noise evaluation will eliminate any future "Victoria Hills Dilema".

ACKNOWLEGEMENTS

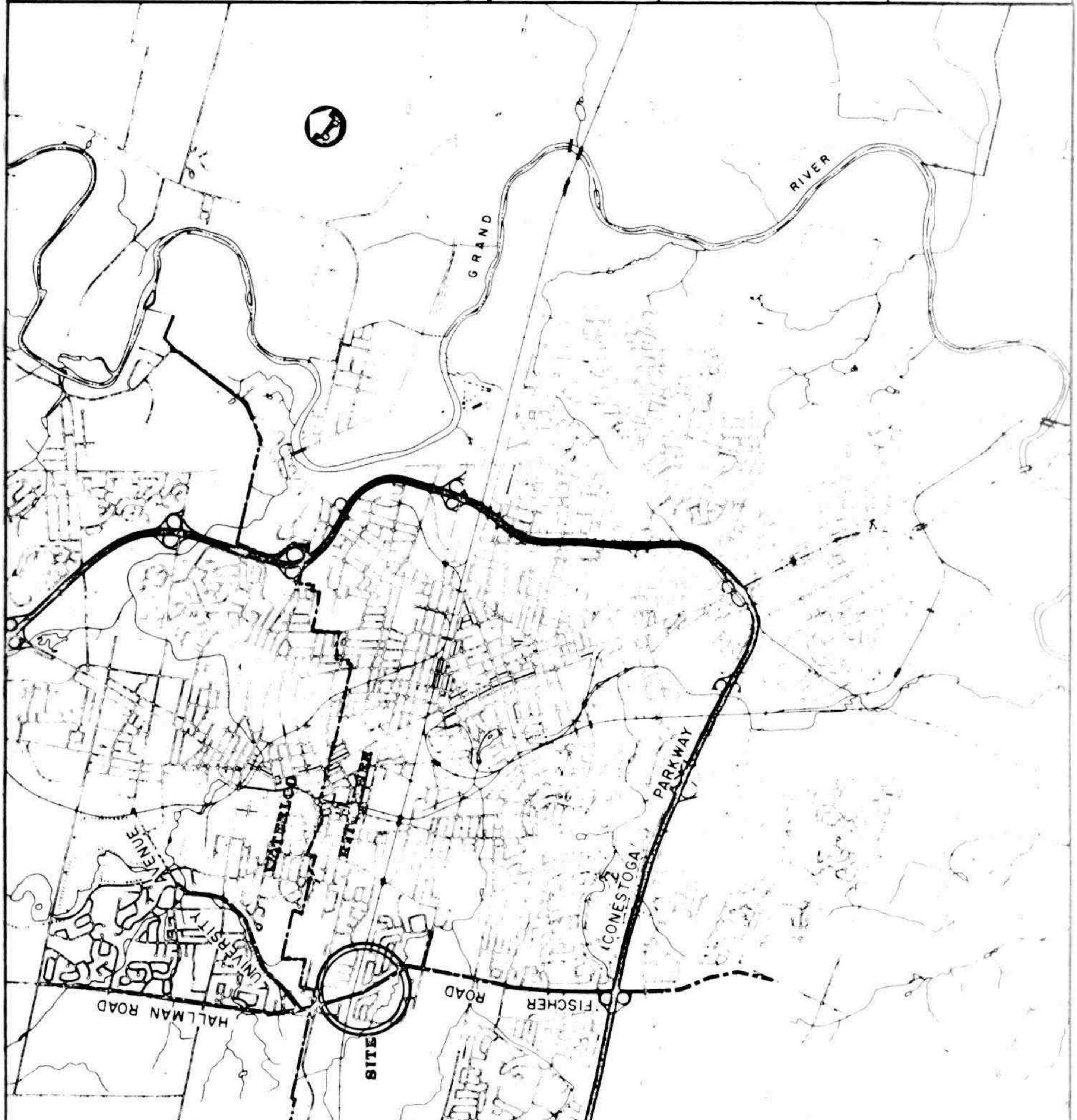
The authors wish to gratefully acknowledge the assistance of Mr. H. Gidamy, P. Eng., of the Pollution Control Branch of the Ministry of the Environment who provided noise meters to measure existing noise levels. Also, without the previous efforts of the staffs of the Regional Municipality of Waterloo, M.M. Dillon Limited, and J.S. Keeler Limited, this paper may not have been possible. To them, our thanks.

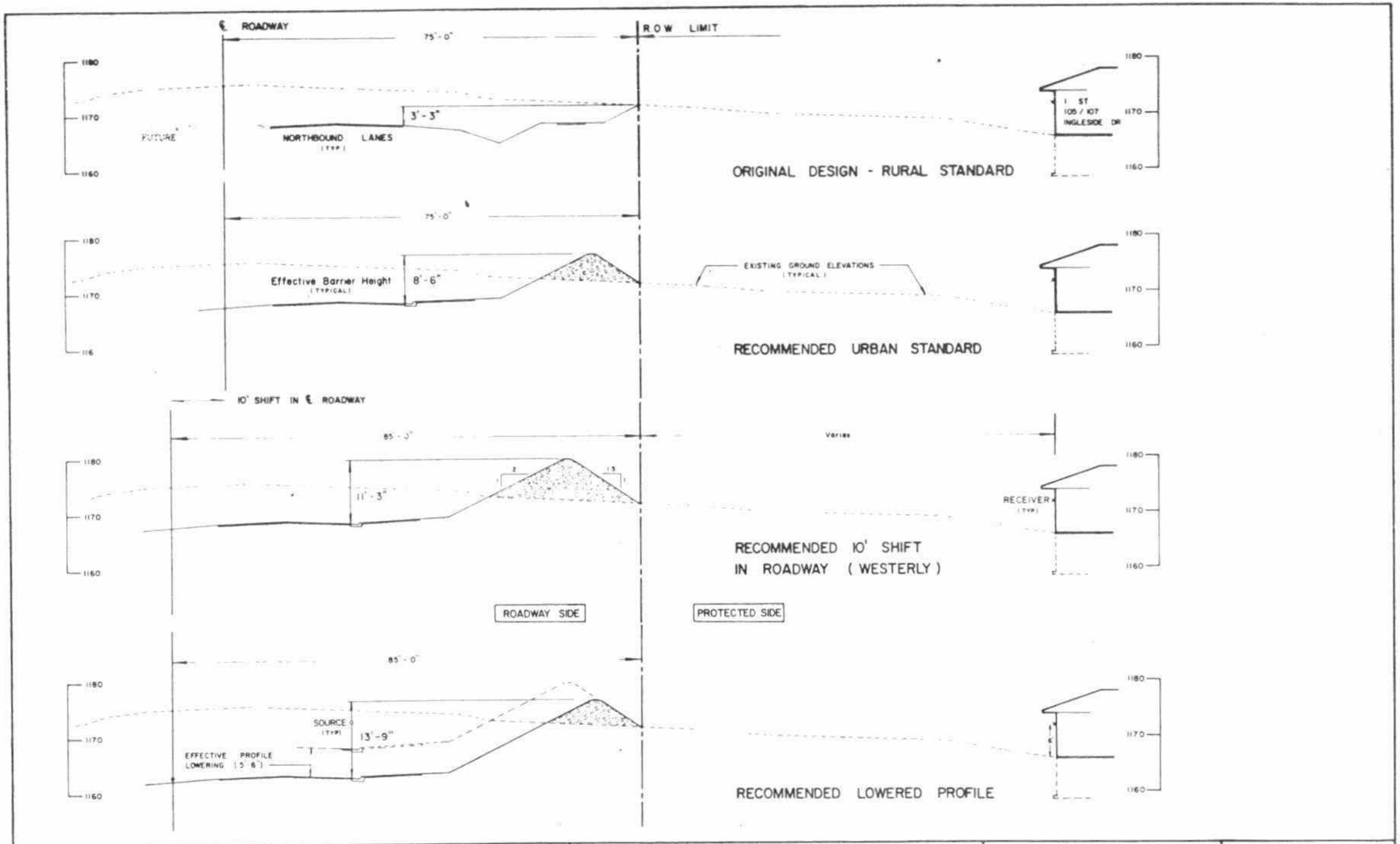
M.M. DILLON LIMITED, CONSULTING ENGINEERS AND PLANNERS, 1978
Fischer-University-Hallman Corridor Predesign Study, Regional Municipality of Waterloo.

MINISTRY OF THE ENVIRONMENT, ONTARIO, JULY 1977
Acoustics Technology in Land Use Planning - Volume 1
Analysis of Noise Impact

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, JANUARY 1975
Ontario Highway Noise Prediction Method, RR197

FISCHER · UNIVERSITY · HALLMAN CORRIDOR NOISE IMPACT ACCESSMENT	KEY PLAN	SCALE: 0 KILOMETRES 1 DATE: MAY 1979	PLATE No. 1





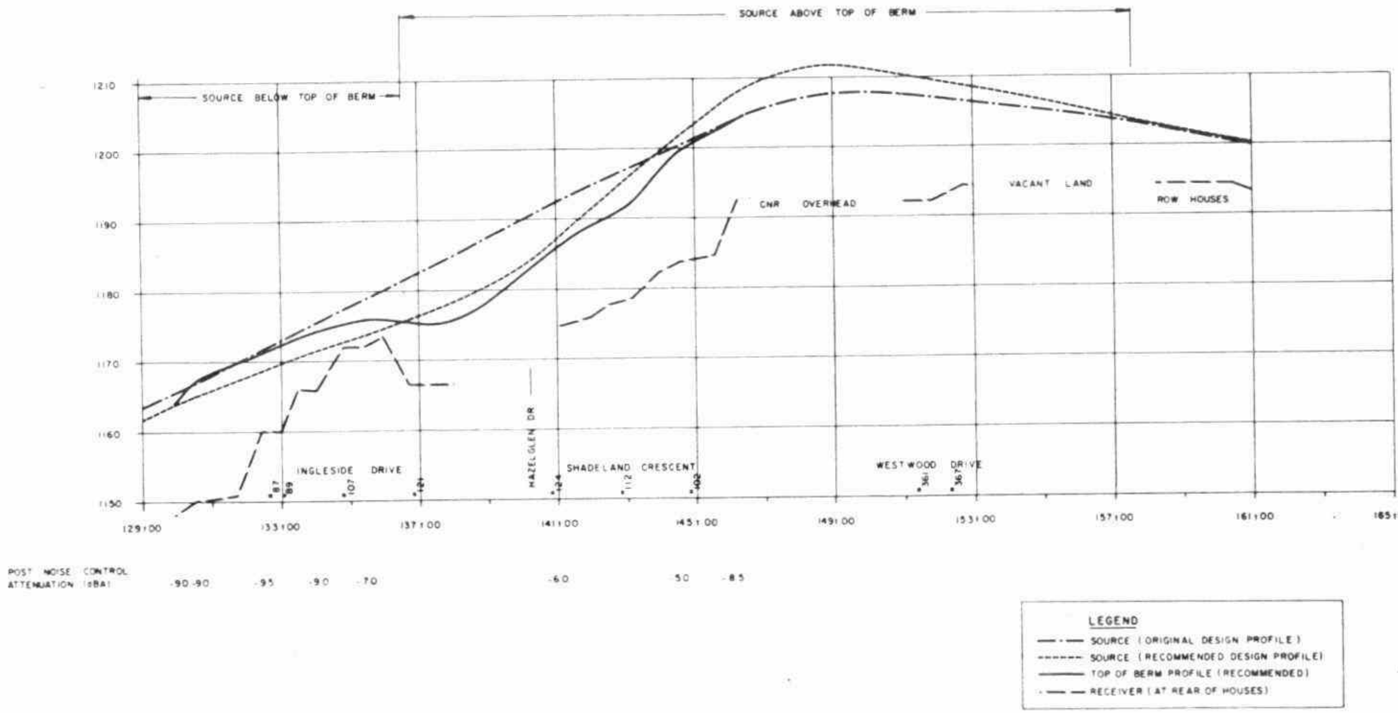
FISCHER · UNIVERSITY · HALLMAN CORRIDOR
NOISE IMPACT ASSESSMENT

IMPACT OF DESIGN MODIFICATIONS
ON BERM HEIGHT AND
SOURCE - RECEIVER SEPARATION
(STATION 135 + 00)

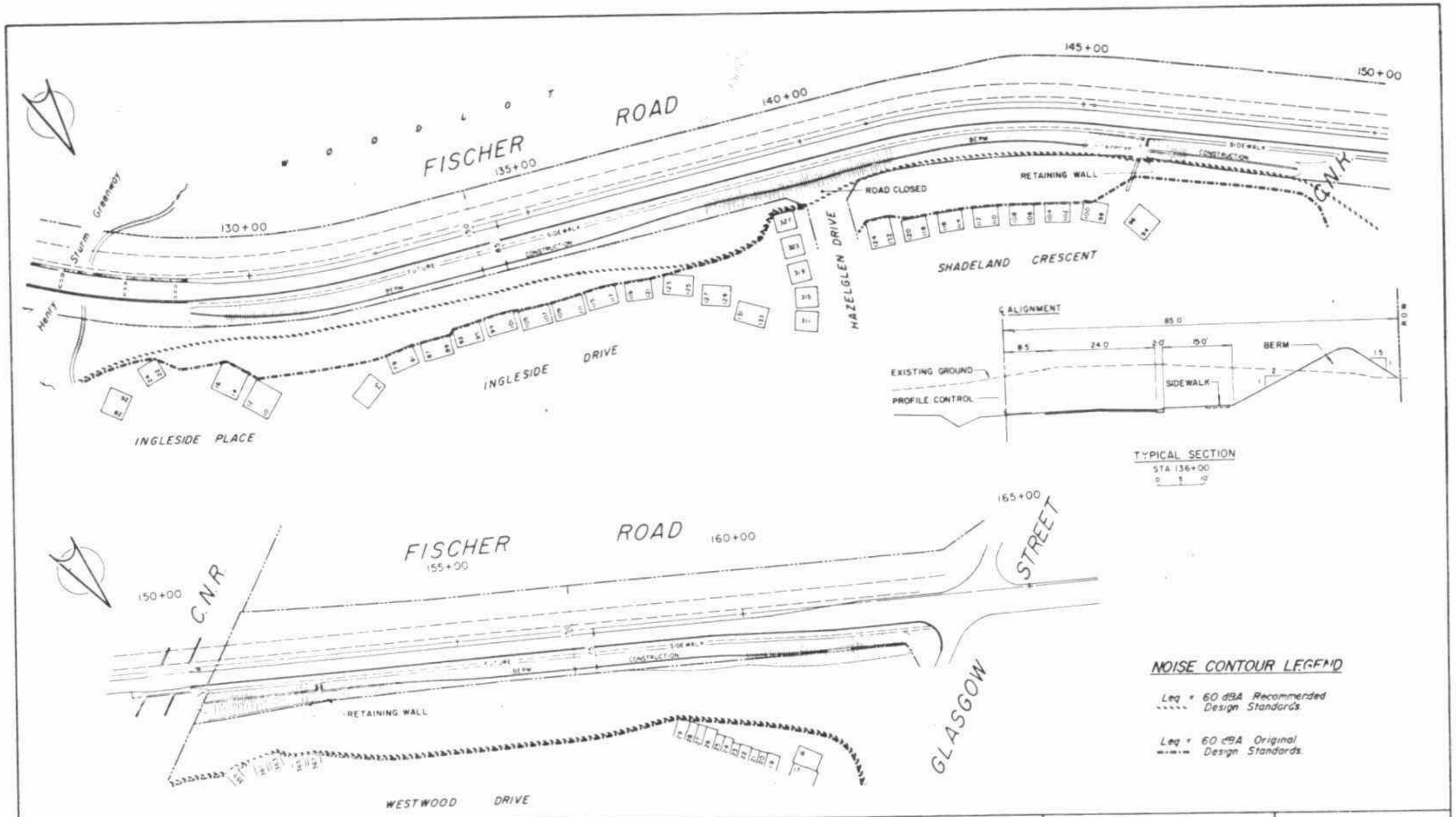
SCALES: Horizontal / Vertical 0 5' 10

DATE: MAY 1979

PLATE No.
2



FISCHER UNIVERSITY HALLMAN CORRIDOR NOISE IMPACT ASSESSMENT	SOURCE / BERM / RECEIVER PROFILES (STATION 129+00 To 161+00)	SCALES Horizontal 0 100 200 Vertical 0 5 10 DATE MAY 1979	PLATE No. 3



FISCHER-UNIVERSITY-HALLMAN CORRIDOR NOISE IMPACT ASSESSMENT	PREDICTED NOISE LEVEL CONTOURS	SCALE: 0 50 100 150 DATE: MAY 1979	PLATE No. 4

Noise Impact Study for a Proposed Residential Development in Ontario: A Case Study

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ABSTRACT

This paper outlines, in the form of a case study, the procedures for forecasting noise impacts from a freeway on an adjacent parcel of land proposed for residential uses, identification of alternative means for indoor and outdoor noise mitigation and the selection and decision-making process.

Methods of traffic noise projections are briefly discussed as well as sound level limits recommended by the Ministry of the Environment, Ontario.

Alternative outdoor noise control measures are described including spatial separation from the noise source, construction of a continuous noise barrier, reorientation of outdoor recreational areas and the use of housing barrier blocks. Indoor noise control measures are also described including architectural design features such as room and corridor arrangements, orientation of windows and blank walls; and the acoustical treatment of walls, doors and windows. An evaluation of each alternative is given which considers such factors as the amount of noise mitigation provided, land values, marketability of various types of residential units, construction costs, aesthetics, maintenance, property requirements, safety, drainage requirements, building materials and energy considerations.

The decision-making process involving the owner of the lands and his consultant, and the Ministries of the Environment, and Transportation and Communications, Ontario, to select a preferrable noise mitigation scheme is discussed. The study recommendations indicate that in this case, satisfactory residential noise levels could be achieved adjacent to a major freeway, with some increase in overall development costs, by the use of a combination of readily available mitigation techniques.

1. INTRODUCTION

1.1 Background

This paper is based on an actual noise impact study undertaken recently by a private land developer for a proposed residential subdivision within the Municipality of Metropolitan Toronto, Ontario. Marshall Macklin Monaghan Limited was the consulting engineering firm assigned to the project.

The owner undertook the study for the purpose of satisfying a condition of draft plan approval set by the Ontario Ministry of the Environment (M.O.E.). Said condition of approval required the owner to investigate the potential noise impact likely to occur from a major freeway proposed to be constructed along the face of his property and to identify feasible noise attenuation measures which could be incorporated into the development of the property to ensure the attainment of an acceptable sound environment.

As illustrated in Figure 1, entitled "Study Approach", the project was carried out in close co-operation with both the Ministry of the Environment and the Ministry of Transportation and Communications (M.T.C.). Meetings and discussions were held regularly throughout the course of the study to solicit advice, to rationalize data and to ensure acceptance of the findings and conclusions.

1.2 Site Location

Figure 2 illustrates the general location of the site and adjacent land uses.

The subject site consists of approximately 140 hectares of undeveloped land bounded by arterial roads along the northern and southern faces; a collector road along the eastern face; and a corridor for a proposed ten lane freeway along the western fringe.

Land uses abutting the site include residential development to the west; a community college to the east; recreational uses to the south; and vacant lands proposed for industrial use to the north.

2. DEFINING THE PROBLEM

2.1 Noise Guidelines

2.1.1 Descriptors

Noise within residential areas is generally measured and expressed in terms of a single descriptor, an A-weighted energy equivalent continuous sound level, Leq. dBA, which is derived by averaging time-varying sound energy and which reflects an annoyance value equivalent to that emitted by the original time varying sounds.

If the predominant noise source under consideration is an industry or a freeway which may produce a near constant sound level then the A-weighted 50th percentile sound level, L50 dBA, is also examined.

2.1.2 Sound Level Limits

The Ontario Ministry of the Environment's recommended sound level limits within residential areas are as follows:

		Leq.	L50
Outdoors:	(7 a.m. - 11 p.m.)	55 dBA	52 dBA
	(11 p.m. - 7 a.m.)	50 dBA	47 dBA
Indoors:	(bedrooms, sleeping quarters)	40 dBA	-
	(other rooms)	45 dBA	-

In areas wherein sound levels conform to the aforementioned limits residential development may proceed without the incorporation of any noise control measures. In areas wherein noise exceeds the recommended sound level limits slightly, by up to 5 dBA, the implementation of noise control measures is optional. If no physical measures are taken then prospective purchasers or tenants are usually advised by a clause in the deed or rental agreement that noise may occasionally interfere with some activities. If the limits are exceeded by more than 5 dBA, the Ministry of the Environment requires the incorporation of satisfactory noise control measures (References 3 and 4).

2.2 Freeway Proposal

The freeway is to be constructed over a period of fifteen to twenty years. The proposed ultimate design provides for a divided ten lane facility to be depressed approximately 3.0 metres below the grade of the site and for the construction of interchanges with both of the adjoining arterial roads.

Upon completion, the freeway would operate at a posted speed of between 80 to 100 km per hour and would carry a traffic volume of approximately 100,000 vehicles per day.

As shown in Figure 2, the freeway alignment is designated through the western portion of the site. The right-of-way proposed by the Ministry of Transportation and Communications, Ontario, provides for the long term physical road requirements but makes no provision for berming or other traffic noise mitigation measures except for the 3.0 metre depression.

2.3 Traffic Noise Projections

In keeping with generally accepted planning procedures, noise levels were estimated for the ultimate planning horizon* on the basis of the projected future freeway traffic volumes, using noise prediction models developed by the Ministry of Transportation and Communications, Ontario (References 1 and 2).

The results of the analysis are presented in Table 1 entitled "Projected Outdoor Noise Levels at Selected Receiver Locations". The locations, labelled A to H are identified in Figure 2 and were selected as being representative of areas wherein residents would experience the greatest noise exposure.

The figures in the table reflect outdoor noise exposure at the ground storey likely to be experienced by residents if the dwellings were constructed without complementary outdoor attenuation features.

The results indicated that the impact of traffic noise would be most severe for dwellings directly exposed to the proposed freeway, and primarily for those located on lots within its immediate proximity. On these lots future noise levels would likely be up to 16 dBA in excess of the recommended sound level limits set by the Ministry of the Environment. In a subjective manner, the future noise levels would be up to three times louder than the recommended criteria and would pose a serious noise problem which would require the incorporation of noise control measures.

3. ALTERNATIVES FOR NOISE REDUCTION

The results of the analysis were reviewed with the Noise Pollution Control Section, Ministry of the Environment, and general concurrence was received with respect to the methodology, the results and preliminary conclusions. The consultant, therefore, set out to define the alternatives available for the attenuation of the excess noise.

3.1 Outdoor Noise Control Measures

Outdoor noise control measures refer to feasible methods of reducing noise levels in outdoor recreational areas such as backyards, patios and common outdoor amenity areas.

Alternative outdoor noise control measures which could be incorporated either individually or in combination into the development of the site were identified to include the spatial separation of noise sensitive uses by means of a distance setback; the construction of a continuous noise barrier; the reorientation of outdoor recreational areas; and use of housing barrier blocks.

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* These procedures have since been revised and a minimum planning horizon of ten years is now recommended (Ref. 3; pps. 68 & 99).

Distance Setback

Since noise decays exponentially with distance acceptable sound levels can be achieved by increasing the separation between proposed residences and the freeway.

Distance setback, in this particular case, would result in acceptable outdoor sound levels in both front yards and back yards, as well as acceptable indoor sound levels without the use of any other special noise control features as will be discussed.

In general, noise reduction by the method of distance setback is more practical in rural areas where land costs are lower. In most urban areas, such as Metropolitan Toronto, land is expensive and distance setback alone can rarely be afforded, unless the intervening land can be used for other compatible uses.

Noise Barrier

A noise barrier is a planned physical structure which is placed between the noise source and the noise sensitive area to reduce undesirable sounds to acceptable levels. Structures employed in many similar circumstances have consisted of solid walls. Occasionally, where both land and surplus earth were available, then earth berms have been constructed.

Earth berms and walls are equally effective in reducing unwanted sounds providing that their design meets the following noise barrier specifications.

A noise barrier must be solid, continuous without holes and gaps and must be sufficiently dense to minimize direct noise transmission. A surface density of 15.0 to 20.0 kilograms per square metre is generally sufficient for most applications.

A noise barrier must be high enough to redirect or reflect sound waves away from observers and it must be long enough to minimize the impacts of waves diffracting around each end.

The location of a noise barrier with respect to the noise source and to the noise sensitive area is also a governing factor. Generally, a barrier's performance can be maximized by locating it as close as possible to the noise sensitive area or preferably to the noise source.

Reorientation of Outdoor Recreational Areas

The backyards of dwellings are customarily used as private areas for the enjoyment of the outdoors and for recreational activities such as relaxation, conversation, etc. Such being the case, the house structure itself can be used as a short finite barrier to provide shielding from excess noise generated by a source located in the front. This method of noise control is primarily effective in the protection of designated outdoor areas of specific units.

To implement this measure, it is necessary to orient dwellings to face the freeway. Access to the dwelling and parking can be provided by constructing a service road within the subdivision adjacent to the freeway as shown in Figure 4.

Alternatively, where lots back on to the freeway, quiet outdoor areas for passive relaxation can be provided on the front side of the dwellings together with the standard driveway leading to the garage by means of innovative housing design as shown schematically in Figure 5.

Careful consideration would be required in the design and layout of the dwelling unit and the individual lots to reflect the intent for use of the front area and to ensure sufficient screening for privacy. Further information concerning outdoor amenities and living areas are presented in Reference 6.

Since the individual dwellings do not comprise a continuous barrier, they are not effecitve in shielding large areas. However, the size of individual areas to be sheltered can be maximized using either appropriate house design, a garage, solid walls extending from the main structure or other effective solid screening. Typically, areas in excess of 60 square metres can be shielded depending upon the type and density of housing.

Housing Barrier Blocks

In this alternative, a row of townhouse blocks or linked dwellings is constructed along the perimeter of the subdivision adjacent to the freeway as an effective alternative to an earth berm or barrier wall to reduce excess noise over a large area. Buildings which are so utilized are called barrier blocks.

Barrier blocks are generally designed to be taller, or alternatively at higher elevations, than the other dwellings to be protected. Outdoor recreational areas associated with the barrier blocks are usually reoriented towards the sheltered side away from the noise source as shown in Figure 6.

To be effective, barrier blocks should be continuous and should be placed as close as possible to the noise source, or preferably the noise sensitive area. The passageway or gaps between the blocks should be minimized and care should be taken in the architectural design and construction of the blocks to ensure acceptable indoor sound levels and to adequately protect the end units.

3.2 Indoor Noise Control Measures

The presentation in Section 3.1 outlined the feasibility of achieving acceptable outdoor sound levels on lots exposed to noise in excess of the Ministry of the Environment's recommended sound level limits. This section examines the requirements necessary to ensure that acceptable sound levels would be achieved within the dwellings to be constructed on such lots.

Measures for the attainment of acceptable indoor sound levels which were considered included architectural design and acoustical treatment using special construction techniques.

3.2.1 Architectural Design

Three different types of architectural designs include room and corridor arrangements, orientation of windows and use of blank walls.

Room and Corridor Arrangements

Annoyance from excess noise can be reduced substantially by locating less-sensitive rooms and spaces adjacent to the exposed walls. Noise-sensitive areas include bedrooms, living rooms and dens where sleep, speech communication and relaxation activities take place. By comparison, kitchens and bathrooms are considered to be less noise-sensitive applications, and closets, storage rooms, corridors and stairways are not considered to be at all sensitive.

Orientation of Windows

From the noise insulation point of view, the window is the weaker link of a wall-window combination. Indoor sound levels can be reduced by locating the windows on walls which are not directly exposed to the noise source. This measure is somewhat complementary to room and corridor arrangements, and its effectiveness depends on the orientation of the wall with respect to the noise source. For windows designed in walls running perpendicular to the noise source, the reduction is limited. If the wall with the windows in it is parallel to the noise source on the shielded side of the house, significant reduction of indoor levels can be realized.

Blank Walls

Significant reduction of noise levels indoors is possible with the use of blank walls on the building facades, overlooking the noise source. The degree of success in using blank walls greatly depends on proper utilization of the above two measures as they will allow proper consideration of other important factors in housing design such as lighting, ventilation and maximum utilization of indoor space. The conventional house plan normally relies on operable window located in opposite walls to provide adequate lighting and ventilation. With the use of one blank wall the flexibility to provide windows is somewhat reduced to one side and care must be taken to ensure sufficient lighting and ventilation.

The application of blank walls is generally confined to extreme cases where the noise problem is serious and cannot easily be resolved by other means.

3.2.2 Acoustical Treatment of Walls, Doors and Windows

If indoor noise levels cannot be lowered sufficiently by the design of the architectural features, further reduction is possible by employing special construction materials and techniques.

The conventional construction techniques and the materials used in walls and doors usually provide adequate sound insulation. The acoustical treatment of the windows include: the sealing of the standard windows in the wall; reducing the size of windows; increasing the glass thickness; and using double glazed windows with an air-gap between the panes.

Generally, the choice of the type of window, door and walls to be used is subject to meeting the required acoustical insulation expressed as an Acoustical Insulation Factor, AIF, (Reference 3 and 5).

This factor takes into account the difference in perceived noise levels outdoors and indoors and the characteristics of each of the components forming the envelope of a room, through which excess noise may penetrate.

4. DECISION MAKING CONSIDERATIONS

The potential benefits and costs associated with each of the noise mitigation alternatives were reviewed with the owner, the Ministry of Transportation and Communications, and the Ministry of the Environment. Some of the major criteria in the selection of appropriate noise mitigation techniques which were considered are outlined in the following sections.

4.1 Distance Setback

If a distance setback were the only means used to reduce excess traffic noise, the required separation between residences and the freeway would be in excess of 200 metres. Further, approximately 40 hectares, representing over 30 percent of the developable site area, would be removed from residential development.

Land values in Metropolitan Toronto precluded the retention of so vast an amount of land as open space. Its development for industrial uses was not considered practical unless the entire area was utilized for industrial uses since the remaining residential area would have been too small to support the necessary community amenities such as schools, recreational facilities etc. Consequently, this alternative was discarded from further consideration.

4.2 Residential Planning

As identified in Section 3.1, row housing can be used to form barrier blocks to shelter a large outdoor area from excess noise. Houses can be oriented along a service road to face the noise source and thus shelter an outdoor area in the backyard or can be designed innovatively to shelter an area in the front yard both from noise and visual intrusion.

Since these alternatives are closely related to marketability, the owner played a significant role in their consideration. The owner indicated that market conditions in the area favoured privately owned single family or semi-detached housing with a conventional subdivision layout and, therefore, they precluded the incorporation of substantial amounts of row-housing and innovative designs. Development of a service road was also rejected on the basis of the higher cost of development for single loaded streets and in the opinion of the developer the anticipation of a poor aesthetic appearance of houses fronting the service road.

4.3 Earth Berms or Walls

4.3.1 Benefits and Disadvantages

The owner indicated a strong preference for the incorporation on-site of a noise barrier, consisting of an earth berm or a wall. He concurred with the consultant that a barrier would not only reduce excess traffic noise, but would also provide a number of associated benefits including a reduction in environmental impacts such as salt spray, dust and roadway debris, a reduction in roadway intrusion caused by vehicle headlights, enhancement of privacy for outdoor recreation, a measure of safety and security attributed to the barrier's relative permanence, and if nothing else, a psychological benefit by eliminating the freeway from the resident's view.

In the owner's opinion, the benefits outweighed the disadvantages which were identified to include maintenance requirements and aesthetics both of which are dependant upon construction techniques and materials, impacts to surface water drainage, snow accumulation, safey, property requirements, and the associated costs.

4.3.2 Barrier Requirements

To reduce on site noise at the ground storey to acceptable levels, it would be necessary to construct a continuous barrier along the entire western boundary of the site for a distance of 1400 metres and, as shown in Figure 3, along the northern and southern boundaries to a distance of approximately 100 metres. The total barrier length required would be approximately 1600 metres.

Along the northern and southern boundaries, the barrier height requirement would be approximately 2.0 to 2.5 metres measured with respect to the site grade. Along the western boundary an effective height of approximatley 3.0 metres would be required.

An analysis of the effectiveness of an earth berm or wall designed to these specifications is presented in Table 2 entitled "Comparison of Projected Outdoor Daytime Noise Levels at Selected Receiver Locations".

4.3.3 Comparison of Options

From discussions with the Ministry of Transportation and Communications, Ontario, several options for the design and placement of a roadside noise barrier were identified. These included the placement of an earth berm, constructed in accordance with the Ministry's preferred design specifications, entirely within a wider right-of-way or entirely on the privately owned land. The Ministry would also concur with the construction of an earth berm, a wall, or an earth berm with a wall located on top of it along the property line subject to the incorporation of security fencing and a one foot reserve.

To assist the client in his selection of a preferred option the consultant undertook an assessment of the major decision making considerations including property needs; construction costs; maintenance requirements and development impacts. A comparison of the property needs and construction costs are presented in Table 3, and the assessment is discussed in the text following.

Property Needs

Property needs in addition to lands designated for the proposed freeway right-of-way were assessed for each of the five options. The results were as follows:

No additional lands would be required for the construction of a barrier wall (Option E). Construction of an earth berm and wall totalling 3.0 metres in height (Option D) would require approximately 1.0 hectare of additional developable residential land.

The requirements associated with a 3.0 metre high earth berm vary depending on the design of the berm and its placement. A 3.0 metre berm straddling the designated right-of-way (Option C) would require approximately 2.0 hectares of additional land. If located entirely on private land (Option B) the earth berm could require up to 4.0 hectares of additional land.

Construction Costs

The construction cost of a continuous noise mitigation wall ranges from about $100 per linear metre for a 1.5 metre wall to about $150 per linear metre for a 3.0 metre wall depending upon the type of construction materials used and foundation conditions. Comparable heights of earth berm were estimated at a cost between $26 and $125 per metre depending upon the availability and cost of earth fill.

Total costs are shown in Table 3. The costs vary from $40,000 to $225,000 depending upon the design and construction techniques used.

Maintenance Requirements

Maintenance for a wall is highly dependant upon the type of materials utilized. Sodded earth berms require regular mowing as well as debris cleanup and weed control. Both walls and berms, especially those aligned in a north-south direction at right angles to prevailing winds, may also result in unusual snow accumulations requiring extra maintenance.

Since berms and walls can act as barriers to drainage, additional drainage channels or underground storm sewers are often required. On this site, the natural drainage from north to south would result in the need for drainage channels/swales along both sides of a berm/wall.

Reliable maintenance of a wall or berm would best be achieved if it were placed entirely within the freeway right-of-way (Option A). This decision would imply a continuing cost to the public and flater slopes for an earth berm alternative to permit grass mowing with motorized equipment. Maintenance of a berm or wall in areas with condominium ownership can also prove successful.

Based upon market conditions, the owner of the lands desired separate lot ownerships. In this case, experience has shown that if the berm or wall is placed entirely on private property then those portions of a berm not visible from backyards of adjacent houses are often poorly maintained and wall maintenance is often irregular, resulting in unsightly colour variations along a wall and ultimately high replacement costs to be borne by residential property owners. However, placement of the property line along the top of a berm can result in satisfactory maintenance with the design of a flat topped berm and is a satisfactory location for the placement of a security fence.

Development Impacts

The location of a berm on private or public property can have an important influence on the permitted residential development.

Generally, residential development is governed by a density limitation on the gross area of the site. Placement of a berm in a widened highway right-of-way (Option A) would reduce the gross area of the site and its development potential.

The proposed construction of the ultimate freeway facility was anticipated in fifteen years whereas, residential uses could be constructed sooner within several years. Noise mitigation requirements until completion of the ultimate freeway construction were anticipated to be relatively low, not requiring a berm or wall. However, if the berm is to be constructed on private lands, it would be necessary to construct it at the same time as the residential subdivision. The road authority while recognizing this time disparity, identified the concerns of established residents over a berm if constructed with the ultimate freeway, as a major consideration in scheduling berm/wall construction in conjunction with the residential development.

4.4 Energy Considerations

The Acoustic Insulation Factors (AIF) identified previously in Section 3.2.2, apply to well-fitted, fully weather-stripped windows and only when these windows are closed. The effectiveness of the sound insulation is considerably reduced if the windows are left open.

Since the windows will remain closed for the majority of the time the Ontario Ministry of the Environment and Central Mortgage and Housing Corporation require that an alternate means of ventilation, either air conditioning or specially designed forced air mechanical ventilation be provided.

To provide acceptable indoor comfort conditions; sound levels, temperature, and humidity, while keeping windows and doors closed, one of the following two design objectives should be given careful consideration:

Heat build-up within the occupied indoor spaces can be removed by reducing indoor temperature and humidity to conditions equal to, or near those found in the outside environment. This can be accomplished with the use of specially designed room ventilators capable of providing up to 10 air changes per hour, or with additional modifications to conventional forced heating systems to allow the introduction of up to 100% fresh air within the occupied spaces during summer time.

Alternatively, controlled temperature and acceptable humidity conditions can be provided within indoor spaces via central air conditioning units for the entire dwelling unit or the use of incremental, or window type air conditioning units within specific rooms.

The following are typical costs of air conditioning units. Prices do not include the cost of duct work, or modifications to the heating system:

Air Conditioning System	Cooling Capacity (BTUH)	Approximate Cost of Unit
Window Type	5000	$ 250.00
Window Type	6000	$ 275.00
Incremental Unit	7000	$ 850.00
Central Unit (2-Ton)	24000	$1,150.00

4.5 Building Materials

Table 4 illustrates the projected indoor sound levels and type of window at selected receiver locations to meet the objective sound levels recommended by the Ontario Ministry of the Environment. As can be seen from the table, the projected indoor sound levels are excessive assuming normal construction and windows open for ventilation and removal of heat build-up during summer time. To meet the indoor sound level limits the type of window should be equal to or better than those shown on Table 4. Moreover, it is important that such windows be kept closed during the warm season in order to provide the required Acoustic Insulation Factor (AIF).

Fortunately in this situation, standard window construction to meet the minimum thermal insulation requirement set by the Ontario Building Code would also meet or, better exceed the required Acoustic Insulation Factor.

Since windows will remain closed for the majority of the time, air conditioning, or specially designed forced air mechanical ventilation system would be required in order to meet ventilation requirements and reduce the increasing difference in temperature between inside spaces and the outdoor temperature.

5. SUMMARY

5.1 Selection of Preferred Measures

After careful consideration of all of the options taking into account the associated benefits, negative impacts, economic feasibility and marketing aspects, the owner elected to incorporate the following measures into his proposed development:

- the construction of a noise barrier along the alignment proposed in Figure 3 to reduce noise at the ground storey level,
- the incorporation of linked dwellings, to the maximum allowable density, adjacent to the ends of the barrier to provide additional shielding for other residences on the site,
- relocation, wherever possible, of balconies and terraces to the shielded side of the dwelling,
- acoustical treatment of exterior walls and windows at upper storey levels,
- architectural revisions to proposed floor plans orienting less sensitive uses towards the side of dwelling exposed to the noise source, and
- central air conditioning.

No final decision was made pertaining to the design of the noise barrier or its placement. These matters are still under consideration by both the owner and the Ministry of Transportation and Communications, Ontario.

5.2 Approvals

Upon completion of the investigation, the analysis and findings were documented in a noise impact report which subsequently was submitted to the Ministry of the Environment for their final review.

Several meetings were held between staff of the Noise Pollution Control Section, the developer and the consultant in the interest of securing the Ministry's approval of the draft plan.

Finally, the draft plan was recommended for approval with the following two conditions to ensure proper implementation of the recommended noise control measures.

A18

a) Prior to final approval and registration of the plan, the Ministry of the Environment shall be notified by a copy of the fully executed subdivider's agreement between the owner and the municipality that the noise abatement features recommended by the acoustical report and any features recommended by the Ministry shall be implemented as approved by requirements of the subdivider's agreement.

b) In the event that a slight noise level excess will remain, despite the implementation of the noise control features, the subdivider's agreement shall provide all subsequent agreements of purchase and sale for lots (to be specified by the noise study) the following warning:

> "The purchasers are advised despite the inclusion of noise abatement features within this development area and within the individual building units, noise levels may still cause annoyance. The purchaser agrees to insert this paragraph in the agreement of purchase and sale and in the deed of the dwelling unit when he sells the unit".

References

1. J.J. Hajek, Ontario Highway Noise Prediction Method, Research Report 197, Ministry of Transportation and Communications, Ontario. January 1975.
2. J.J. Hajek, Ontario Leq. Prediction Method, Ministry of Transportation and Communications, Ontario, June 1976.
3. Ministry of the Environment, Ontario, Acoustics Technology In Land Use Planning - Volume 1, Analysis of Noise Impact 1977
4. Ministry of the Environment, Ontario, Model Municipal Noise Control By-Law, Final Report. August 1978.
5. Central Mortgage and Housing Corporation, Ottawa, Ontario Road and Rail Noise: Effects on Housing, NHA 5/56, December 1977.
6. Central Mortgage and Housing Corporation, Ottawa, Ontario, Site Planning Criteria, NHA 5/43, August 1977.

Table 1

PROJECTED OUTDOOR NOISE LEVELS AT SELECTED RECEIVER LOCATIONS (Unattenuated Noise at Ground Storey Level)

Receiver Location[1]	Distance From Highway Pavement (metres)	Daytime				Nighttime			
		Leq.		L50		Leq.		L50	
		Level (dBA)	Excess[2] (dBA)	Level (dBA)	Excess (dBA)	Level (dBA)	Excess (dBA)	Level (dBA)	Excess (dBA)
A	60	69	14	68	16	62	12	59	12
B	120	63	8	62	10	56	6	53	6
C	180	60	5	60	8	54	4	51	4
D	60	69	14	68	16	62	12	59	12
E	120	59	4	58	6	52	2	49	2
F	60	69	14	68	16	62	12	59	12
G	120	63	8	62	10	56	6	53	6
H	180	60	5	60	8	54	4	51	4

1) Receiver locations are identified in Figure 3.

2) Excess above the Ontario Ministry of the Environment's recommended sound level limits.

Table 2

COMPARISON OF PROJECTED OUTDOOR DAYTIME NOISE LEVELS AT SELECTED RECEIVER LOCATIONS

Receiver Location[1]	Distance From Highway Pavement (metres)	Leq. Analysis				L50 Analysis			
		Without Attenuation		With Attenuation[3]		Without Attenuation		With Attenuation	
		Level (dBA)	Excess[2] (dBA)	Level (dBA)	Excess (dBA)	Level (dBA)	Excess (dBA)	Level (dBA)	Excess (dBA)
A	60	69	14	60	5	68	16	59	7
B	120	63	8	58	3	62	10	57	5
C	180	60	5	57	2	60	8	57	5
D	60	69	14	60	5	68	16	59	7
E	120	59	4	50	-	58	6	49	-
F	60	69	14	60	5	68	16	59	7
G	120	63	8	58	3	62	10	57	5
H	180	60	5	57	2	60	8	57	5

1) Receiver locations are identified in Figure 3.

2) Excess above the Ontario Ministry of the Environment's recommended sound level limits.

3) Refer to text.

Table 3 COMPARISON OF PROPERTY REQUIREMENTS AND CONSTRUCTION COSTS

Option(1)	Location	Property(2) Needs (hectares)	Construction Costs
A - Earth Berm Height - 3.0 metres	Entirely within(3) Highway Right-of-Way	+2.0	$40,000 - $180,000
B - Earth Berm Height - 3.0 metres	Entirely On Private Land	+4.0	$40,000 - $180,000
C - Earth Berm Height - 3.0 metres	Straddles Highway and Private Lands Equally	+2.0	$40,000 - $180,000
D - Earth Berm & Wall Height: Berm - 1.5 metres Wall - 1.5 metres Total 3.0 metres	Straddles Highway and Private Lands Equally	+1.0	$175,000 - $225,000
E - Wall Height - 3.0 metres	Along Property Line Separating Private Lands from Highway	0.0	$225,000

1) Earth berms designed to Ministry of Transportation and Communications, Ontario preferred specifications including 3:1 side slopes and a 3.0 metre wide flat top.
2) Property needs in addition to lands designated within Ministry of Transportation and Communications proposed right-of-way.
3) Would require a widened right-of-way.

Table 4 PROJECTED INDOOR SOUND LEVELS AND TYPE OF WINDOW AT SELECTED RECEIVER LOCATIONS

Receiver Location	Distance From Hwy. Pavement (Metres)	Outdoor(1) Leq. dBA		Indoor, Leq. dBA, Windows Open	Excess dBA Windows Open	Required(2) Acoustic Insulation Factor (AIF)	Type of Window(3) (Minimum Requirement to Eliminate Noise Impact)
A	60	D	69	59	14	31	Single pane of 24 oz.
		N	62	52	12	29	
B	120	D	63	53	8	25	Single pane of 18 oz.
		N	56	46	6	23	
C	180	D	60	50	5	22	-
		N	54	44	4	21	
D	60	D	69	59	14	31	Single pane of 24 oz.
		N	62	52	12	29	
E	120	D	59	49	4	21	Single pane of 18 oz.
		N	52	42	2	19	
F	60	D	69	59	14	31	Single pane of 24 oz.
		N	62	52	12	29	
G	120	D	63	53	8	25	Single pane of 18 oz.
		N	56	46	6	23	
H	180	D	60	50	5	22	-
		N	54	44	4	21	

1) D = Daytime, N = Nighttime

2) Assuming number of components = 3 (Ref. 3)

3) Assuming 16% window area to total floor area of room (Ref. 3)

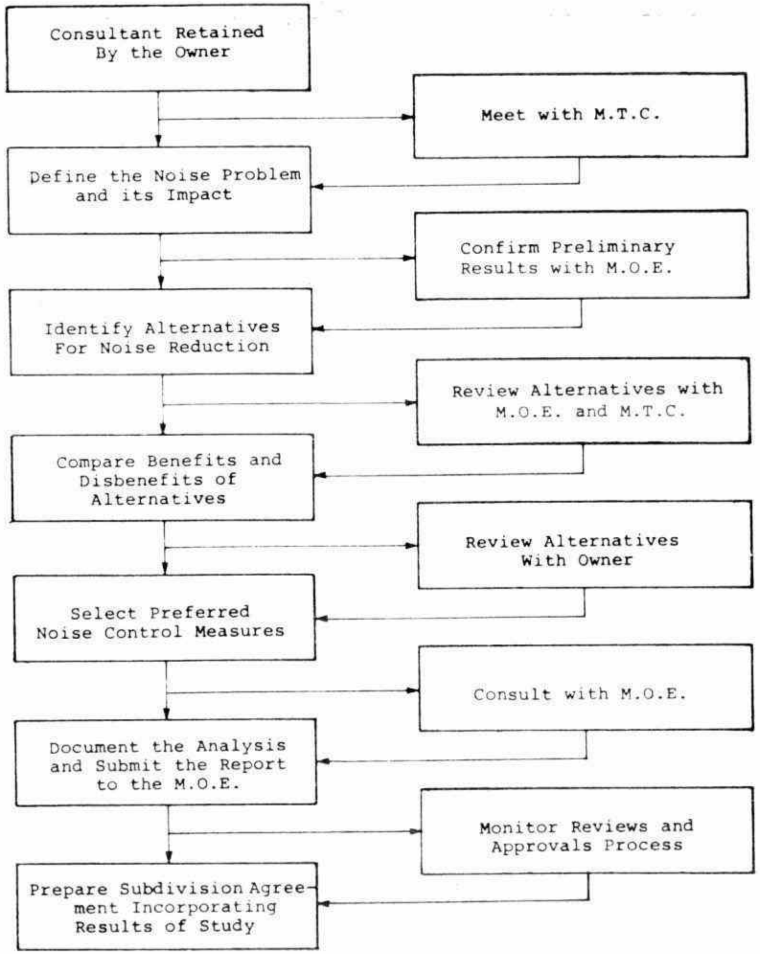

Consultant Retained By the Owner
Meet with M.T.C.
Define the Noise Problem and its Impact
Confirm Preliminary Results with M.O.E.
Identify Alternatives For Noise Reduction
Review Alternatives with M.O.E. and M.T.C.
Compare Benefits and Disbenefits of Alternatives
Review Alternatives With Owner
Select Preferred Noise Control Measures
Consult with M.O.E.
Document the Analysis and Submit the Report to the M.O.E.
Monitor Reviews and Approvals Process
Prepare Subdivision Agreement Incorporating Results of Study

FIGURE 1

STUDY APPROACH

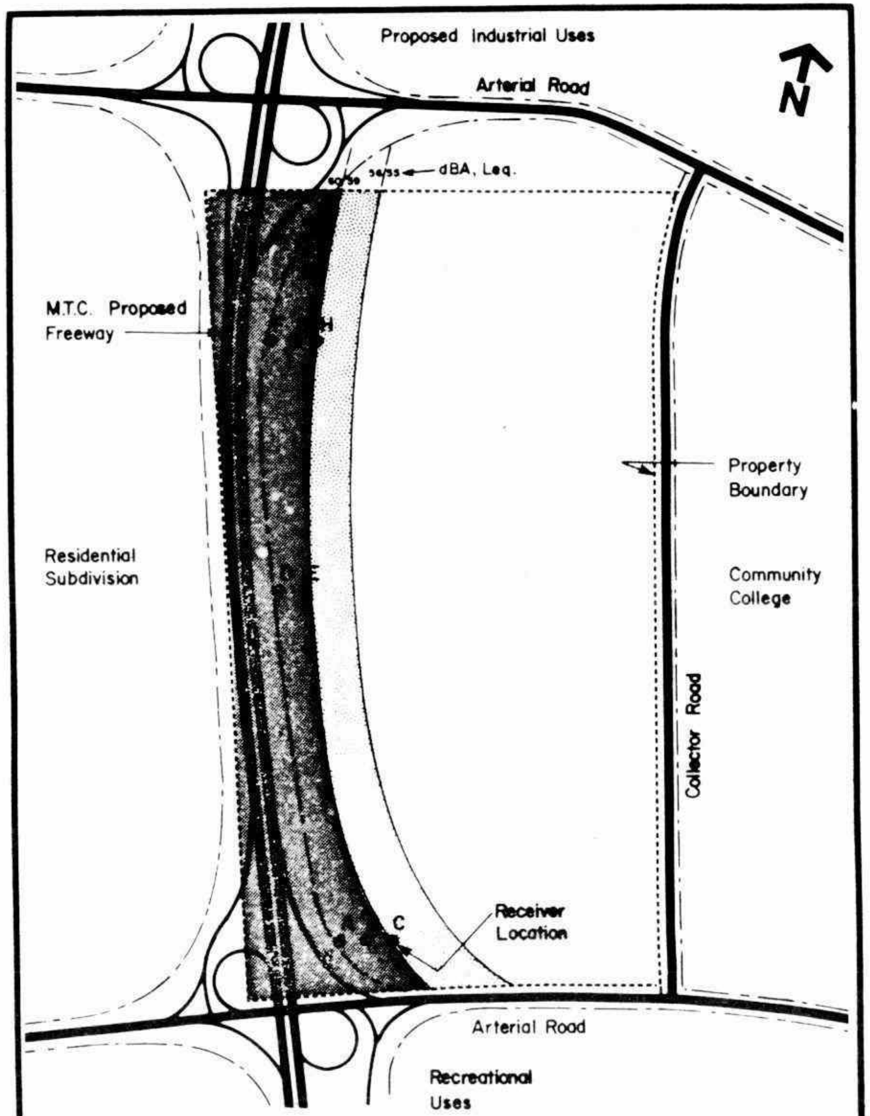


FIGURE 2

KEY PLAN ILLUSTRATING PROJECTED FUTURE UNATTENUATED NOISE LEVELS

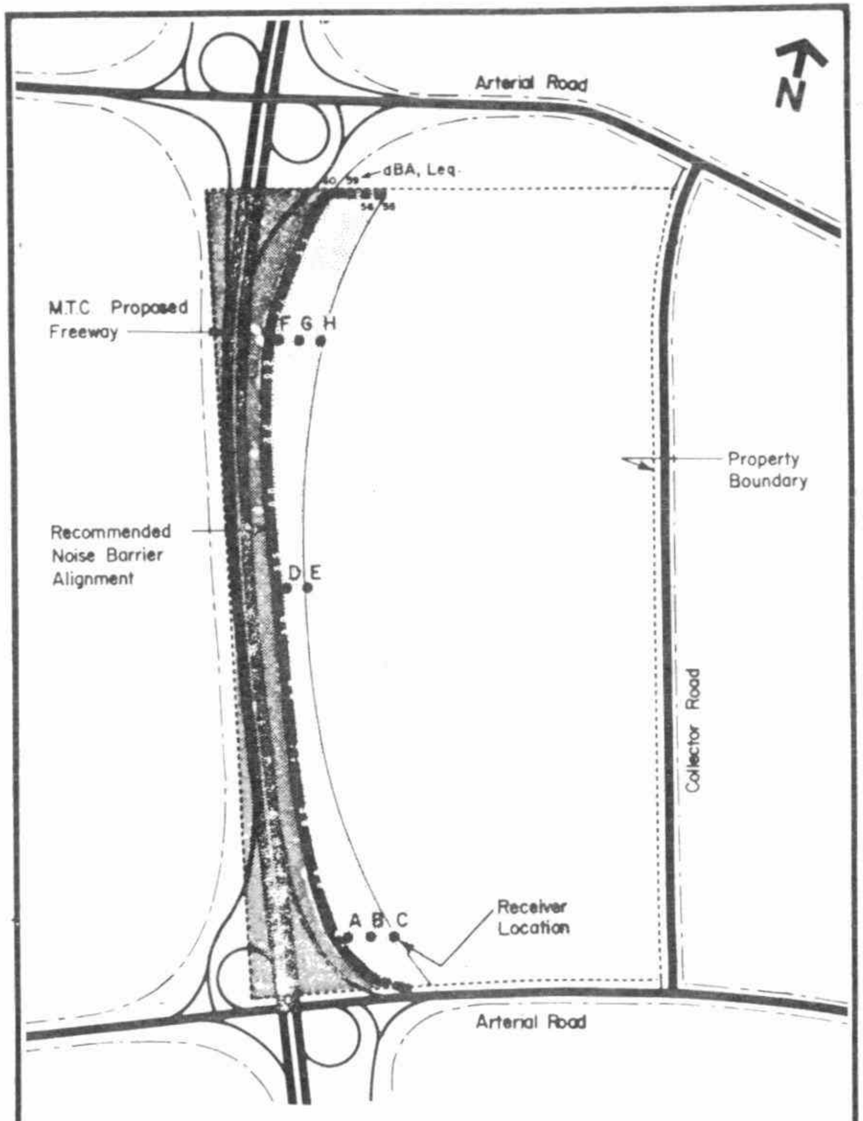


FIGURE 3

PROJECTED FUTURE ATTENUATED NOISE LEVELS

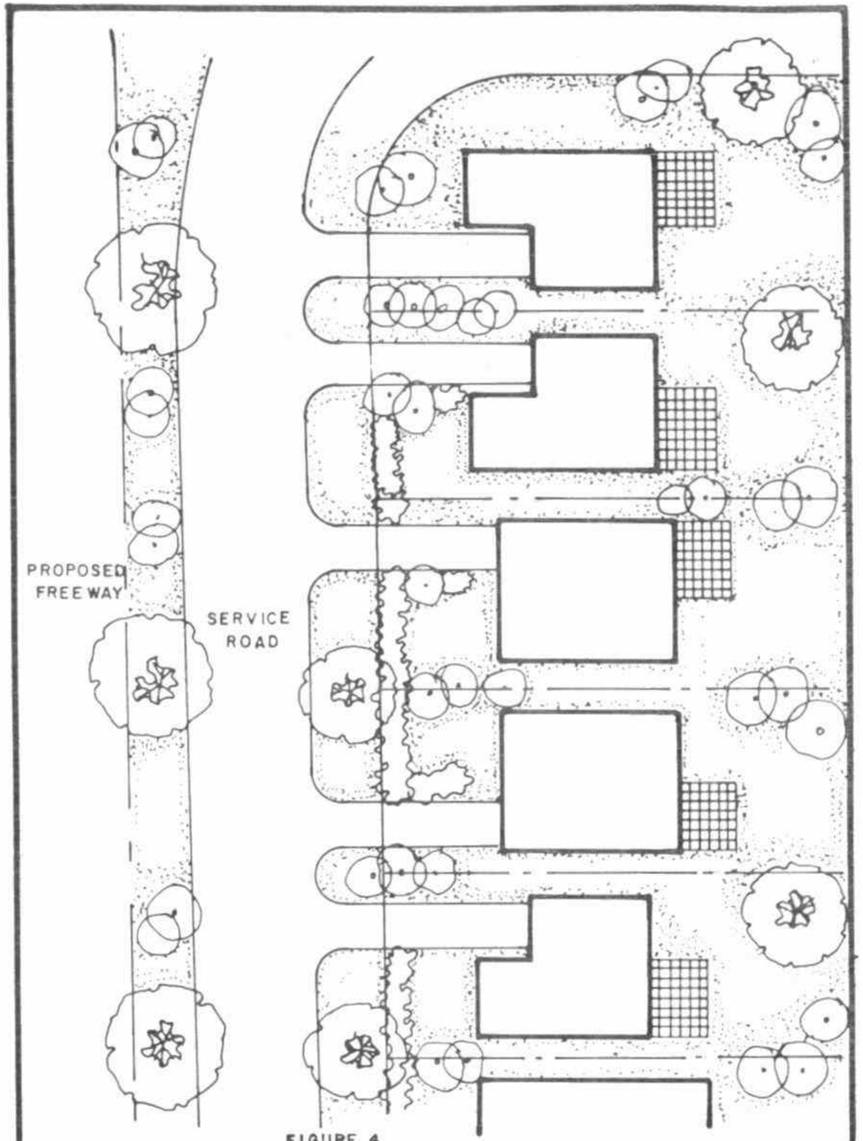


FIGURE 4

REORIENTATION OF OUTDOOR RECREATION AREAS USING A SERVICE ROAD

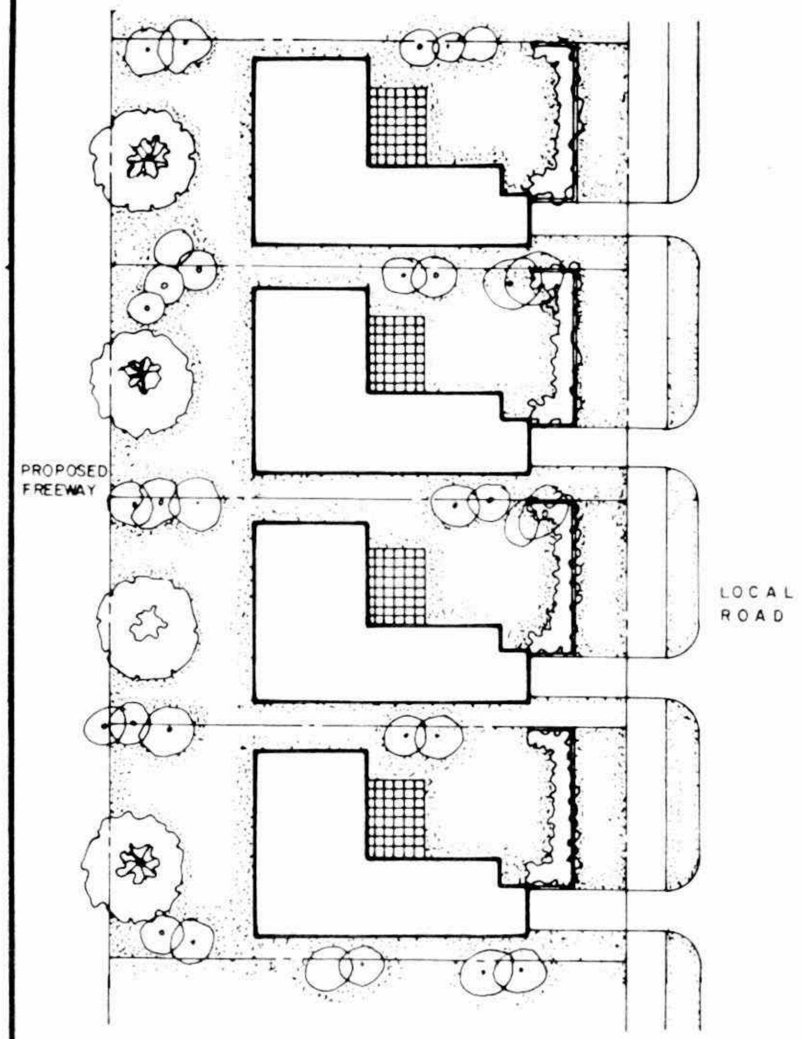


FIGURE 5a

REORIENTATION OF OUTDOOR RECREATIONAL AREAS USING INNOVATIVE HOUSING AND LOT DESIGN

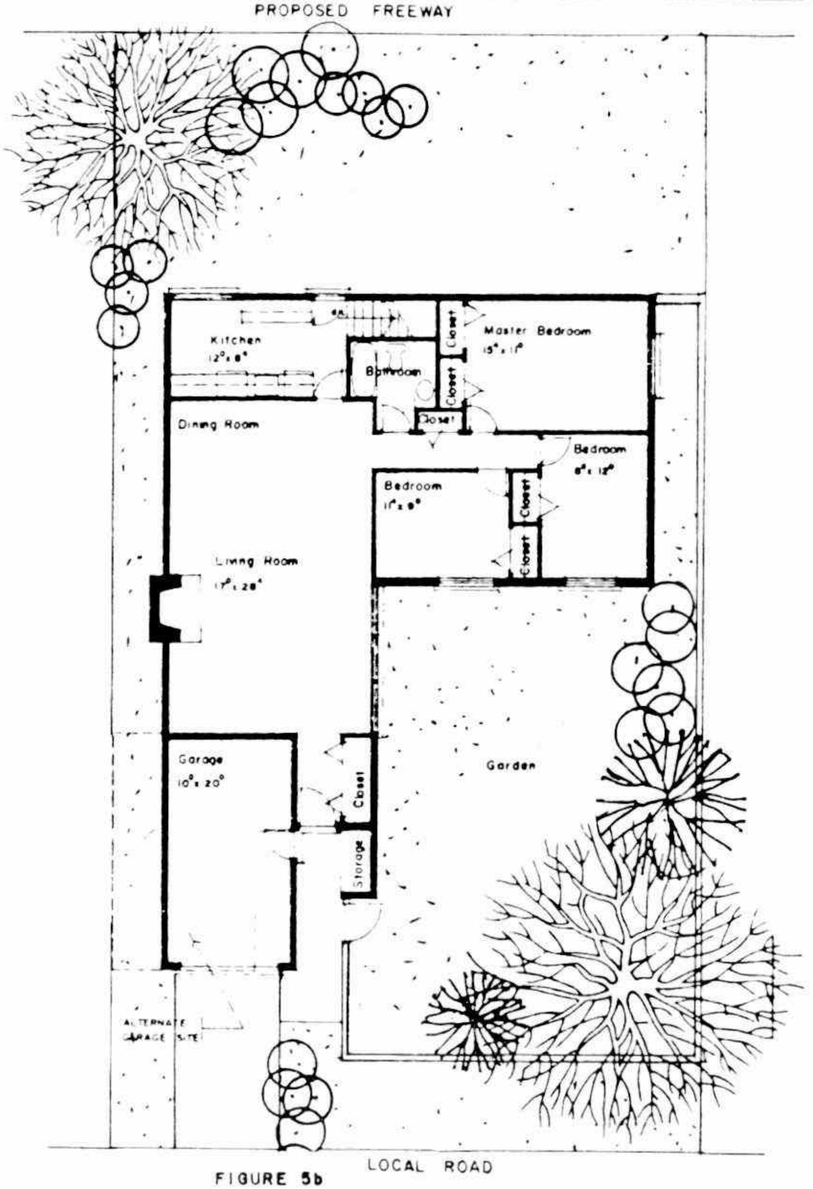


FIGURE 5b

DETAILS OF HOUSE AND LOT DESIGN

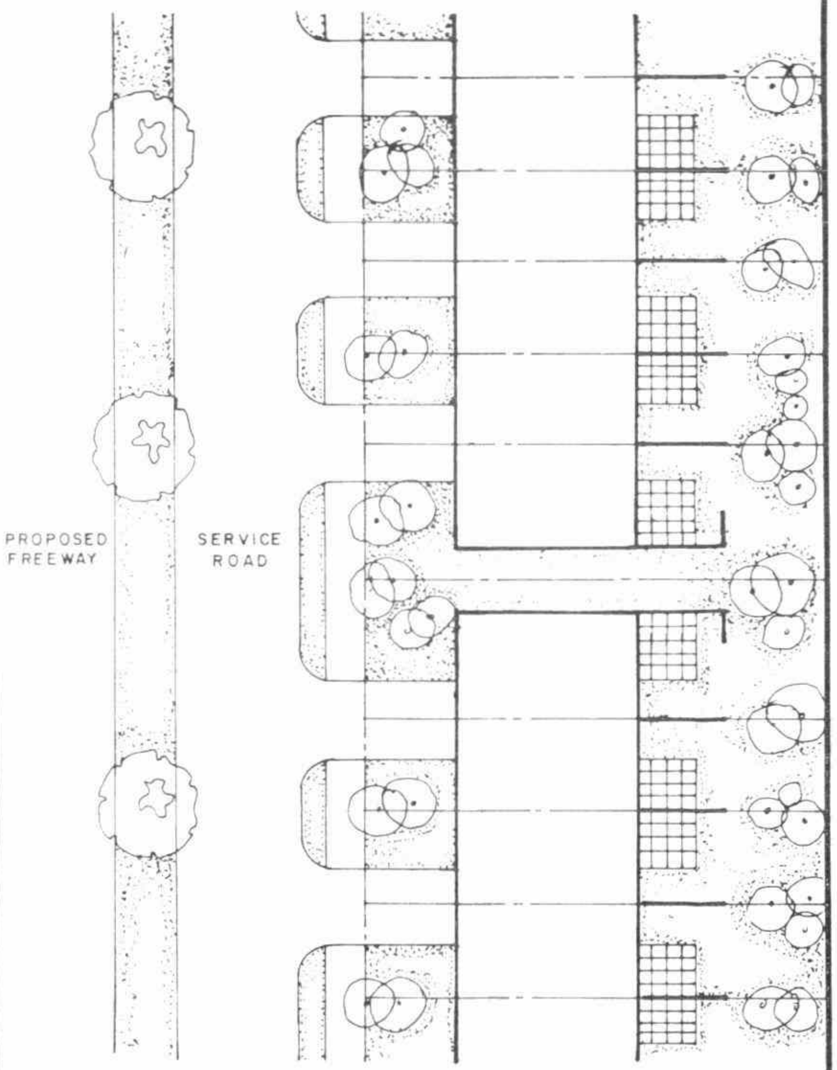


FIGURE 6a

SCHEMATIC OF HOUSING BARRIER BLOCKS USING A SERVICE ROAD

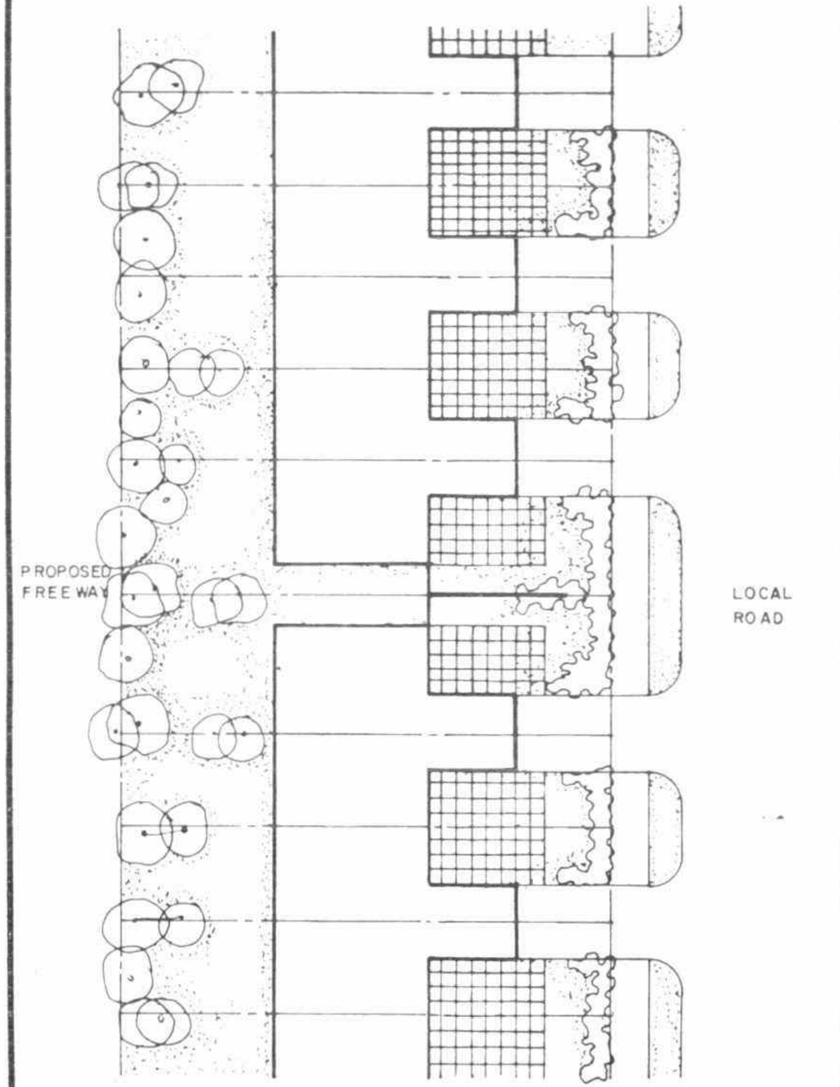


FIGURE 6b

SCHEMATIC OF HOUSING BARRIER BLOCKS USING INNOVATIVE DESIGN

Design of Noise Barriers

Jack Wear
Head, Detail Design Section
Design and Construction Branch
Highway Engineering Division
Ontario Ministry of Transportation and Communications
Downsview

This paper was originally presented at the
1979 RTAC Meeting in Regina, Saskatchewan.

DESIGN OF NOISE BARRIERS

Abstract

Within the past decade, the Ontario Ministry of Transportation and Communications (MTC) has been responsive to an ever increasing need to mitigate noise for residents living in close proximity to major urban freeways.

The paper for RTAC 1979 outlines the experience of MTC in identifying the impacts associated with constructing major transportation facilities and the means of providing a degree of relief.

Initial attempts of providing a noise barrier were not encouraging with lack of effectiveness and high cost. Further attempts at visual relief were again not satisfactory. Subsequent experimentation with a privacy fence indicated that with an effective design approach, success could be achieved with barrier walls that would benefit the public. Noise relief would only be partially achieved but the cost effectiveness would be reasonable.

Additional attempts at noise barrier design and construction verified that the Ministry's approach was reasonable and effective. Various problems developed, however, in the attempt to minimize costs as outlined for a specific barrier.

A noise barrier program was established and a policy developed that would be responsive to the public need.

A computer prediction technique was established and refined to provide adequate prediction for barrier performance.

A benefit/cost analysis was developed to ensure that a prioritization for selection of candidate sites for construction would be equitable for the public.

Before and after social surveys have provided sufficient indication of reasonable success with the Ministry's approach for the design of noise barriers.

INTRODUCTION

The Ontario Ministry of Transportation and Communications began a program in the latter 1960s following widening of the MacDonald Cartier Freeway, Highway 401 through Metropolitan Toronto from essentially four lanes to twelve lanes to provide a continuous screen of large Austrian Pine. The trees were planted in single and double rows and were expected to provide adjacent built-up residential development with privacy and possible relief from dust, fumes and noise.

Although the plantings initially provided to a limited degree a visual barrier, it would be many years before the trees would mature and provide an effective screening.

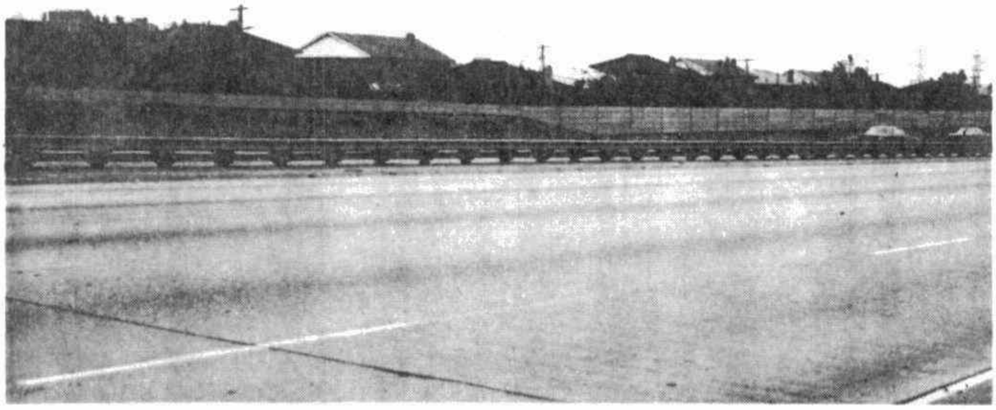
It became apparent to both the public and the Ministry that for all the benefits to be derived from the limited planting of trees that there would not be satisfactory relief from noise. The basic 98 m (300') Right-of-Way for initial construction of the Highway was thought to be sufficient for transportation requirements of the future. However, most of this reserve would be taken for the expansion to provide additional through lanes, weaving sections from core to collector and interchanges with ramps, etc. The remainder as a "buffer" area would provide little opportunity to provide dense screening for residential development without introducing roadside hazards.

MTC INITIAL NOISE BARRIER

In early 1970, the Ministry undertook a demonstration project of a noise barrier. The barrier was constructed in 1971 along Hwy. 401 between Dixon Road and Hwy. 427. Materials chosen were combinations of pre-cast and lightweight cellular concrete panels, with and without earth berms. The barrier approximately 2 km (1.2 miles) in length averaged about 3 m (10') in height above the pavement.

In 1972, an evaluation of its effectiveness revealed a noise reduction of from 1 to 3 dB(A) for the properties immediately adjacent. This reduction was determined as barely perceptible and hence noise barriers were deemed to be relatively ineffective. (Ref. 1).

Dixon Road
to Hwy 427
Hwy 401
Toronto

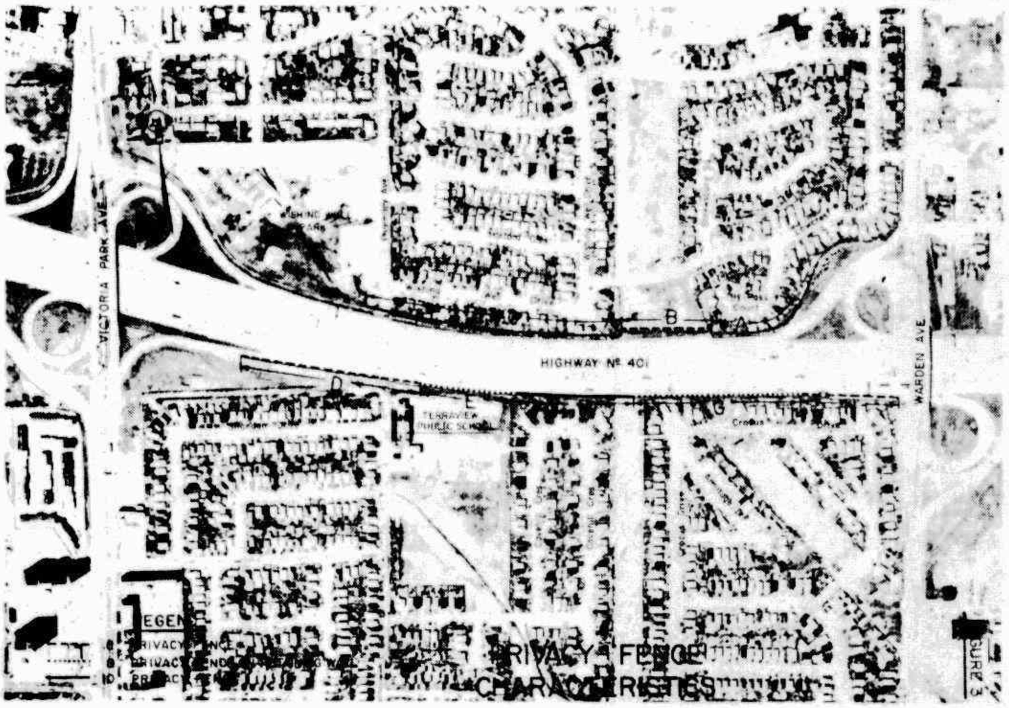


At the same time that MTC had its initial trial with noise barriers, the Municipality of Metropolitan Toronto constructed a number of barriers along the Don Valley Parkway. Various walls made up of aluminum panels, plywood panels, rock (gabions) and pre-cast lightweight cellular concrete were subsequently assessed by MTC with no further indication of success in providing adequate noise attenuation.

Advancements in the "state of the art" for means of effectively reducing noise from Highways would have to be left for future consideration particularly in view of high costs inherent with barrier walls.

MTC PRIVACY FENCE

The Ontario Ministry of Transportation and Communications placed a renewed interest in providing screening and substantial plantings of trees and bushes on major freeways, a position that was accepted by the Ontario Cabinet in July 1973. This evolved from discussion with residents living behind barriers who perceived reduced headlight glare, increased privacy and diminished salt spray. The screening originally would be metal panels fastened to the chain link security fence at the property limits. A demonstration area was selected along Hwy. 401 between Victoria Park and Warden Avenue. Residents in this area initially objected to the concept of a metal barrier as being too thin to adequately lower noise levels and too low to adequately reduce the view of passing vehicles. Considering the "privacy fence" was not designed to reduce noise or vibration, the choice of metal was retained with a mounting separately on steel posts to heights of 3 m or less (10' and 8') in order to screen effectively all the passing vehicles. This decision was arrived at from a short trial section of 2.6 m (8') barrier height and community response that followed. The cost however increased fourfold from the original concept. Plantings were preferred by residents at one end of the barrier rather than a barrier extension.



Steel
Panel
Privacy
Fence

8' - 26 gauge
10' - 24 gauge

Toronto

A steel privacy fence almost 1.5 km long was installed in November 1974. Residents however could not evaluate barrier performance until after the Summer of 1975. MTC concluded from before and after noise measurements that reasonable noise attenuation had been achieved of 5 dB(A) with reductions of up to 9 dB(A) in the yards immediately adjacent. These results could be further improved with sealing of leaks at the bottom of the panels and joining of barriers at transition areas from wall mounting to ground mountings.

A summary of findings (Ref. 2) from the demonstration of the privacy fence revealed that for the first row of homes, the barrier reduced noise in the yard and in the house to a major annoyance; reduced fumes, and dust in dirt in both the yard and the house to minor problems; and reduced salt spray, litter, privacy, transients, headlight glare, and flying stones to an acceptable level. Although noise was a very serious annoyance prior to the installation of the fence, a reduction of 5 dB(A) did not result in tolerable levels being attained. There was sufficient evidence however, that such noise reductions were encouraging and could even be predicted using available highway noise prediction methods.

Considering a privacy fence is not designed to reduce the most significant annoyance to homeowners, i.e., noise and that a very high investment cost is required, the Ministry of Transportation and Communications has not been able to substantiate such a program.

SECOND GENERATION NOISE BARRIERS

The continual concern expressed by residents to the Ministry for noise intrusion from freeways with expansion and improvements of highway facilities, increase in traffic volumes and greater and heavier truck movements, prompted MTC in 1976 to identify those communities where the noise problem would be perceived to be greatest. The partial success of the privacy fence, and experience by other authorities resulted in two sites being selected as candidates for noise barriers. The sites were verified through the use of The Ontario Noise Prediction Method which was developed in 1975 by the Acoustics Office of MTC and has become widely accepted based on the noise descriptor L_{eq}. (Refs. 3 and 4).

In order to ensure that cost effective designs could be determined for the initial and future noise barriers, an extensive investigation into the availability of various materials and barrier systems for MTC was conducted.

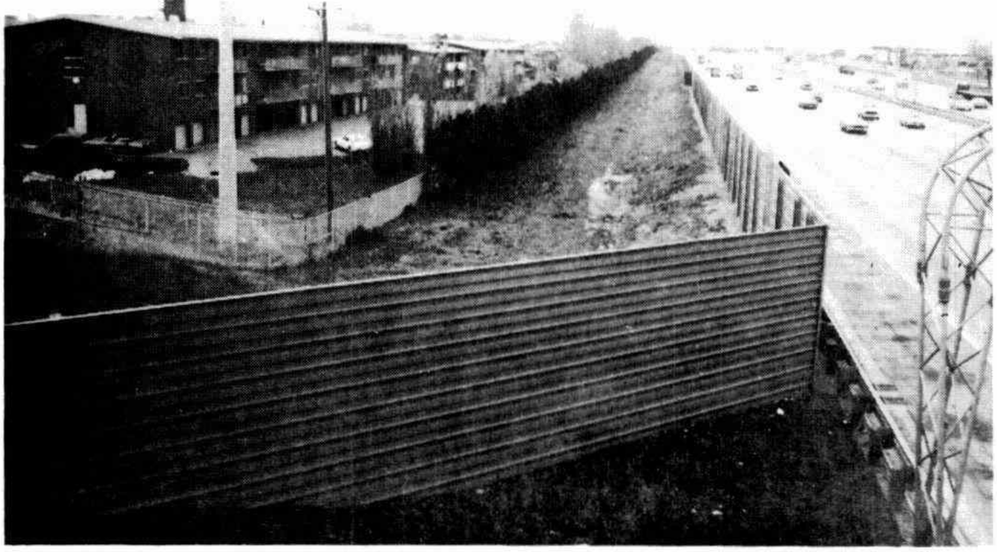
The steel fabricating industry, concrete precasters and other suppliers of wood and synthetics were invited to submit designs for barriers. From those submitted, only steel, concrete and timber were deemed to provide reasonable initial cost and long term performance.

The barrier sites chosen for 1977 were in Toronto on Hwy. 401 between Dixon Road and Kipling Avenue for 1 km (3000') of a 4 m barrier and in Ottawa on the Ottawa Queensway between Melrose and Loretta Avenue for 0.66 km (2000') of a 3 m barrier.

Barrier designs chosen would permit initial variety and experience with the competitiveness and acceptability for potentially a long term barrier program. Numerous public meetings were held to obtain public input and to explain the basis for the experimental program.

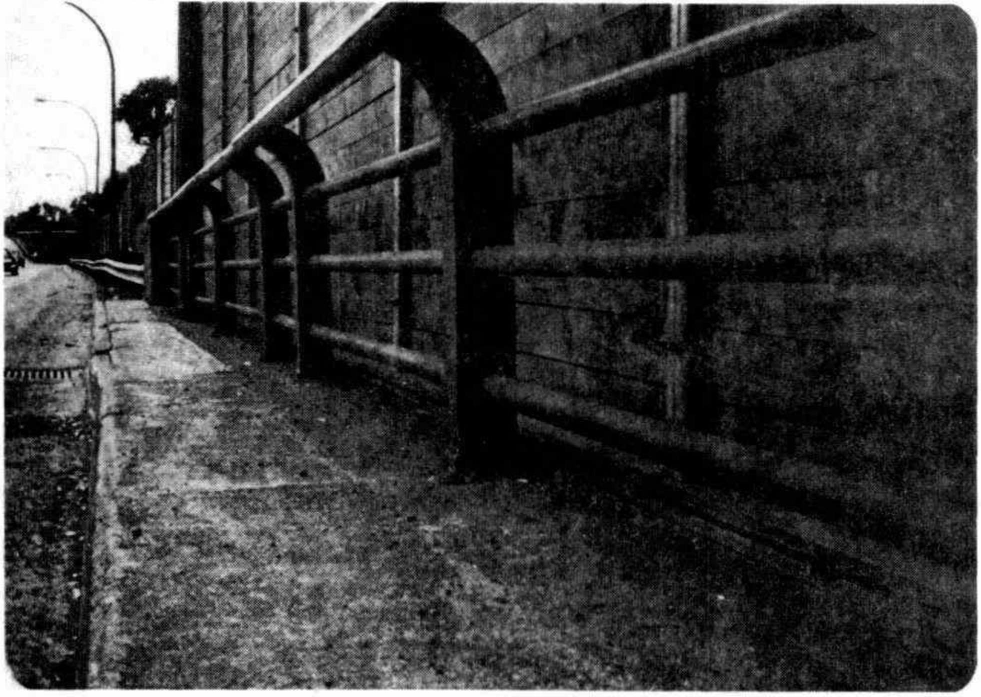
The Toronto site was tendered with pre-established designs for both a steel barrier having horizontal panels and a colour the same as the former privacy fence (Pacific Turquoise), and a concrete panel and steel post arrangement. The lowest bid and that constructed was steel. Barrier cost including supply and installation approximated \$120.00 per linear metre (\$40.00 per linear foot).

Dixon Road
to Kipling
Avenue
Hwy 401
Toronto



The Ottawa barrier was chosen to be wood with options of either 3" x 6" or 3" x 8" nominal tongue and groove horizontal timber planking stacked between cold rolled pre-fabricated posts at approximately 3 m (10') centre to centre; and choices of wood either untreated California Redwood or Western Red Cedar or pressure treated pines such as Jackpine, Whitepine, Logepole, Ponderosa. The barrier constructed was of 6" nominal pressure treated Ontario White Pine at an installed cost of approximately $174.00 per linear metre ($54.00 per linear foot).

Melrose to
Loretta
Avenue
Ottawa
Queensway
Hwy 417
Ottawa



MTC NOISE BARRIER COMMITMENT

As a result of the success with the privacy fence, the anticipated benefit of noise reduction provided from the Toronto and Ottawa noise barriers, the degree of accuracy with which existing noise and barrier attenuation could be predicted, the concern from the public to provide relief from noise on urban freeways and the environmental sensitivity reflected in the Environmental Assessment Act passed in November 1975, the Ontario Government in February of 1977 announced a program to provide, where feasible, barriers on freeways through existing residential areas wherever substantial attenuation could be achieved and at a reasonable cost.

Appropriation of funds was assigned to retrofitting existing freeways and new construction/reconstruction projects. Funds were limited through economic constraints and it was therefore necessary to develop a rational approach for prioritization of noise barrier sites.

MTC NOISE POLICY

Following a commitment to a noise barrier program and the restraint imposed on expenditures for the program in view of the capital expenditure as would be required for all candidate sites, the Ministry adopted the following criteria for the retrofit program:

- The existing facility is a freeway in an urban semi-urban or rural environment with existing and adjacent residential development
- A minimum of four (4) lanes
- A permissible maximum of 72 dB(A) L_{eq} or lower to be achieved based on either level of service 'C' when traffic level is exceeded or the average of the maximum hourly volume for the 3-hour period producing the highest L_{eq}.
- The noise barrier to provide a minimum of 5 dB(A) average attenuation
- Candidate sites to be based on benefit cost consideration and mutually agreed upon between Region and Priority Development Branch.

The attenuation measures for both new construction/reconstruction and retrofit will include a standard Ministry barrier of 4 m average height with flexibility of being higher or lower and not less than 3 m high comprised of a wall, an earth berm or combination of berm and wall. Higher barriers may be permitted in extenuating circumstances of undulating terrain, optimizing barrier locations, etc.

In actual design practice an attenuation between 5 and 10 dB(A) is expected to be obtained from a barrier height of 4 m. This height was established on the basis of the highest benefit/cost and is of a sufficient height to mask all vehicles including trucks.

NOISE PREDICTION TECHNIQUES

In order to derive a reasonably accurate and uniform basis for determining noise levels before and following barrier installation, the Ministry of Transportation and Communications chose with sufficient confidence a theoretical approach rather than actual measurements, investigated several computer prediction techniques and found the most suitable system for Ontario to be that of the BBN Design Guide Computer application that would complement the Ontario Highway Noise Prediction Method for L_{eq} (Refs. 3 and 4). Several refinements to the program were made by staff of the MTC Computer Systems Branch for time savings in production runs, etc. During analysis of several sites it was necessary to adjust the results wherein the attenuation resulting from barrier insertion loss was optimistic by 2 dB(A).

The input for the program requires hourly traffic volumes for the highest level of noise under level of service C with operating conditions of 80 km per hour (50 mph), the volume and composition of truck traffic, the location and configuration of dwellings including the number of stories, topographical data and features. Traffic volumes and composition are required for the freeway, arterial cross roads, ramps, connections and local roads. Pavement type is optional and important only when circumstances such as grooved pavements are present.

It is intended that designers of barrier systems would be able to analyse each barrier site. Extensive documentation and familiarization with the computer prediction technique, however, is necessary. The Acoustics Office of MTC currently provides the acoustic design advice where the site is either too complex or a number of barrier alternatives involving multiple locations and/or heights are under consideration.

A study was conducted with the use of the benefit cost analysis to determine the optimum location (best acoustic performance) for a noise barrier relative to the noise source and receiver. The results (Ref. 5) suggest that for flat terrain, the optimum barrier location is near the receiver and for roadways raised above the Right-of-Way by 1.3 m (4') or more, the optimum barrier location is more beneficial near the highway. This is subject to verification by a detail design analysis.

BENEFIT/COST DEVELOPMENT FOR CANDIDATE BARRIER SITES

Following identification in 1976 of over 160 potential noise barrier sites on freeways with existing and adjacent residential development, many factors were considered in determining an equitable arrangement for prioritizing such sites. An empirical model was deemed suitable as follows.

A benefit/cost number was derived for most sites, the numerical relationship of which is influenced by the following:

> The number increases directly with the noise level existing at a particular site, the amount of noise reduction that can be provided by a barrier, the number of residences protected by the barrier where noise from the freeway would exceed 57 dB(A) L_{eq} in the recreational area and decreases with the cost of the barrier required to provide the noise reduction.

In detail the index number $= \dfrac{\text{Benefit x 1000}}{\text{Cost}}$

where Benefit $= \sum_{i=1}^{n} \Delta Li\ (Li - 57)$ and

Cost = cost of barrier and associated work expressed in dollars

n = number of residences affected with existing (predicted) noise level that exceeds 57 dB(A). High density multiple dwellings are considered for the ground floor only for each unit.

Li = existing (predicted) noise level at each residence 1.3 m (4') above the ground in the recreational area of the property

57 = desirable noise level (L_{eq} is the average noise over a one hour period at a level service C). (Level of service C is comparable to traffic noise between 09:00 and 15:00).

ΔLi = noise attenuation provided by a barrier for each residence of 'n' residences

The length of the barrier is considered in both the coverage it provides for residences and the overall costs.

Work associated with barriers includes installation of guide rail, fence removal, utility adjustments, etc.

The Ministry of Transportation and Communications having performed an analysis for approximately 106 sites is able to review the index number, for example, with changes to existing sites by increases in traffic and additional development in the community under consideration. A review of potential sites is then conducted in the 'Fall' of each year for the following year's program.

SOCIAL SURVEYS OF BARRIER IMPACT

In order to obtain a measure of barrier success on the quality of life, social surveys were conducted before and following second generation barrier installations in Toronto and Ottawa. Control sections without a proposed barrier were used for comparison of results. Noise measurements were also taken before and following barrier erection.

Results of social surveys generally indicate that each barrier has provided a degree of relief for both acoustic and non-acoustic annoyances. (Ref. 6).

Barrier attenuation for the Toronto and Ottawa sites averaged 7 and 6 dB(A) respectively. (Refs. 7, 8 and 9).

The Toronto site was initially a site having much more discontent with noise. The noise was prominent from both freeway and the glidepath of runway 32 right to the Toronto International Airport. The study made an attempt to deal only with noise from the freeway.

Residents in the Ottawa area were more pleased with the attenuation provided by their barrier due to the lower initial noise even though the barrier height was less. A few residents living opposite the barrier have expressed displeasure in additional noise resulting from reflection. Noise measurements have verified a negligible increase of approximately 1 dB(A) due to reflection.

In general, it can be concluded that the higher the noise, the more discontent is evident and the necessity for as high a noise attenuation as technically, administratively and economically practical.

Additional information from residents in the same survey having received a barrier when asked to comment on the choice of barrier materials expressed in the order of their preference, concrete, the barrier provided to them, and lastly steel in Ottawa and timber in Toronto.

Following a third generation barrier constructed of a 4 m Durisol barrier in 1978 along Hwy. 401 between the Don Valley and Victoria Park for 1.6 km and comprised of cemented wood chips with a reinforced mesh concrete backing, a preliminary social survey revealed a dissatisfaction with the appearance of concrete. Residents would prefer a change in colour and landscaping to complement the barrier.

Don Valley
Parkway to
Victoria
Park
Hwy 401
Toronto

DESIGN OF NOISE BARRIERS - A Case Study

One of the second generation noise barriers selected for the first installation on the Ottawa Queensway in Ottawa was the timber barrier previously illustrated.

The barrier location is between Melrose and Loretta Avenue on the North side of the Queensway. Due to a relatively high roadway embankment, the barrier could only practically be located on the shoulder of the existing facility for its full length of 0.66 km (2000'). In order to provide protection to the adjacent community the barrier was required to cross two existing bridges.

The horizontal timber planking was chosen for its aesthetic value to provide a natural appearance for the greenbelt maintained by the National Capital Commission (NCC). Municipal officials and residents from the area attended a public meeting early in 1977 to learn of the Ministry's barrier program and to view and endorse the proposal.

Complication developed for the actual barrier location when it was learned that a buried Hydro plant was installed in the same vicinity as the proposed barrier. Further, electrical underground wiring supplying power to the existing lighting installation would also have to be relocated.

The initial barrier design was based on selecting 3 inch nominal thickness due to concerns by MTC Maintenance staff of the District for possible excess loading during snow ploughing operations. A 2" nominal thickness would have been adequate for satisfactory acoustic attenuation. Barrier height was chosen as 3 m due to protection partially afforded to the residents by the existing embankment. Structurally for wind loading of 20 p.s.f., a maximum 3.3 m (10') post spacing was chosen.

Galvanized steel posts similar to those used in the privacy fence erected previously along Hwy. 401 were chosen.

The barrier design would permit the timber planking to be retained within the returns of the fabricated steel posts and minimize distortion of the timber elements following barrier erection. The planking could be 6" or 8" nominal depth. The deeper sections would minimize distortion and potential noise leaks. Planks were to be tongue and grooved to prevent distortion and noise leaks.

At a late stage in the barrier tendering process, the additional option of pressure treated timber was offered as a competitor to the California Redwood and Western Red Cedar previously specified.

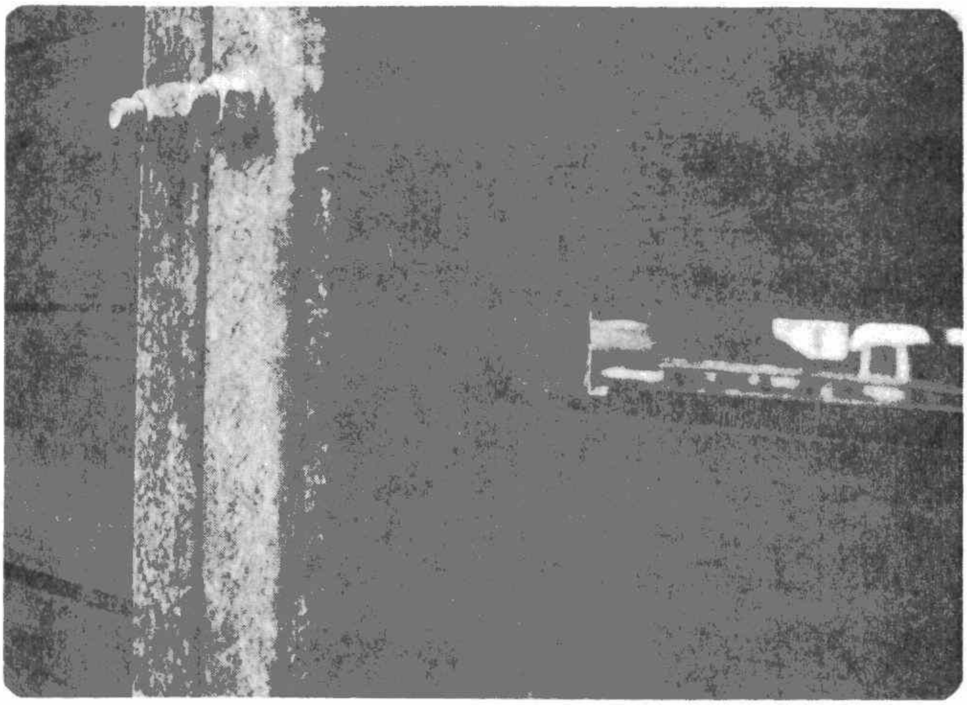
The installation of the barrier would be facilitated by permitting closure of the adjacent lane of the Queensway during off peak traffic periods.

Following award of the contract in mid-1977, the erection of posts commenced without the benefit of timber being available. Although the Contractor chose pressure treated pine, there was a delay in acquiring the timber and a supply of white pine from the treator was the only material available. An extension of working days for the contract was approved due to the shortage of timber.

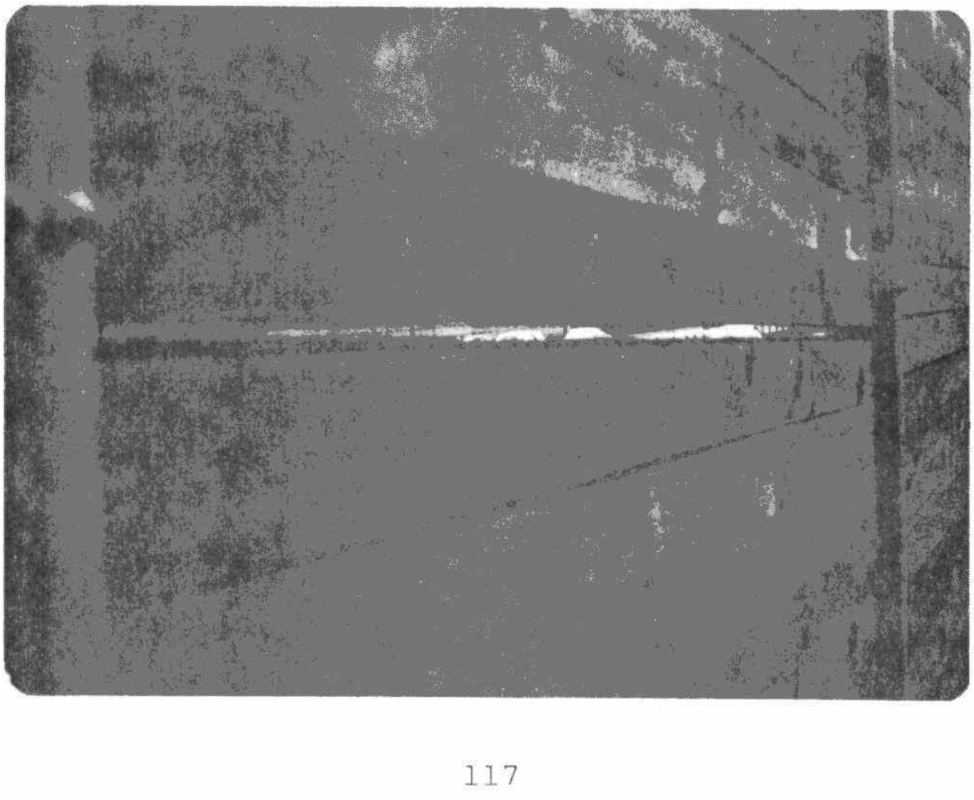
There were no further complications in completing the barrier and the installation was satisfactory for line and grade. The barrier was completed prior to the Winter of 1977-78.

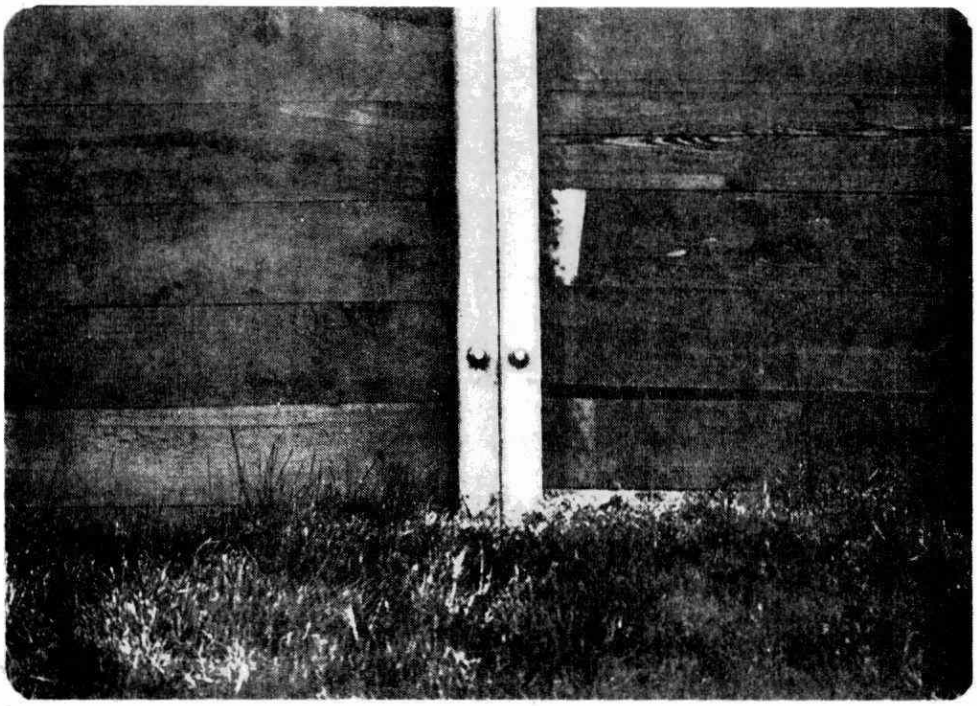
The following pictorial account provides insight to conditions that should be considered in timber barrier installations.

The following Spring of 1978 noise measurements were taken, and it was readily apparent that noise leaks were evidently degrading the barrier performance. Instead of achieving an expected 6 dB(A) attenuation, the barrier was providing only 3 dB(A) average. A review of the conditions revealed how the individual planking had shrunk and/or settled and due to inherent design limitations the planking was being held from dropping in its stacked arrangement by the bolts at mid height through the planking and posts.

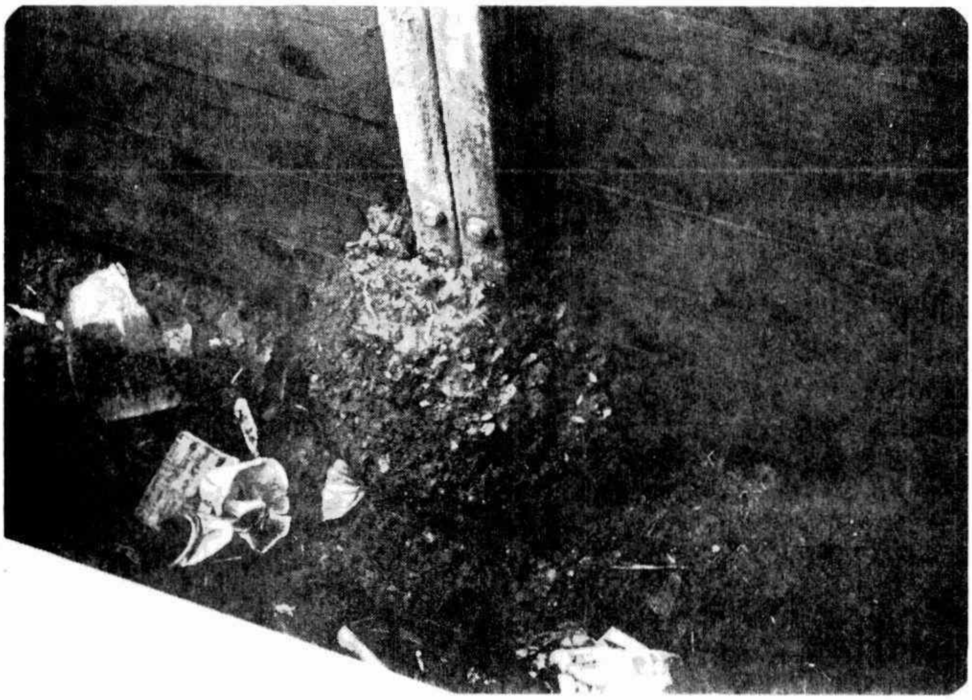


The photo above illustrates a gap which is an extreme case. A 25 cent piece is wedged in the upper plank in order to compare the size of the opening. The photo also reveals a portion of the tongue that is missing. The settlement is further illustrated as not being uniform. It is possible that frost action may have contributed to either preventing the planks from settling or permitted such uneven settlement including the posts possibly illustrated in the following photographs.

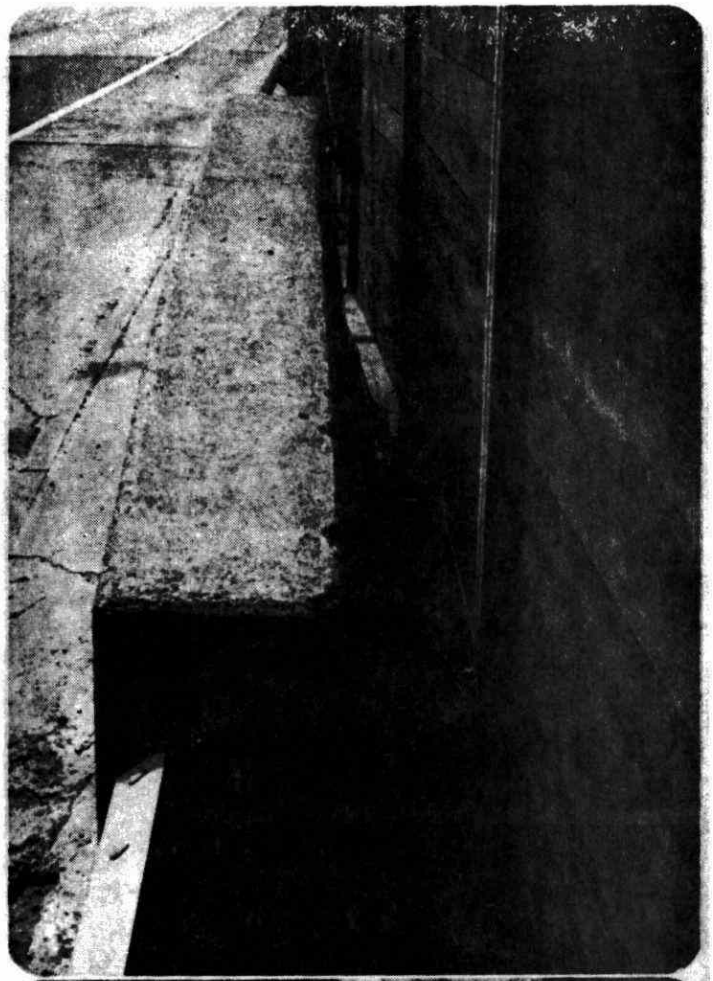




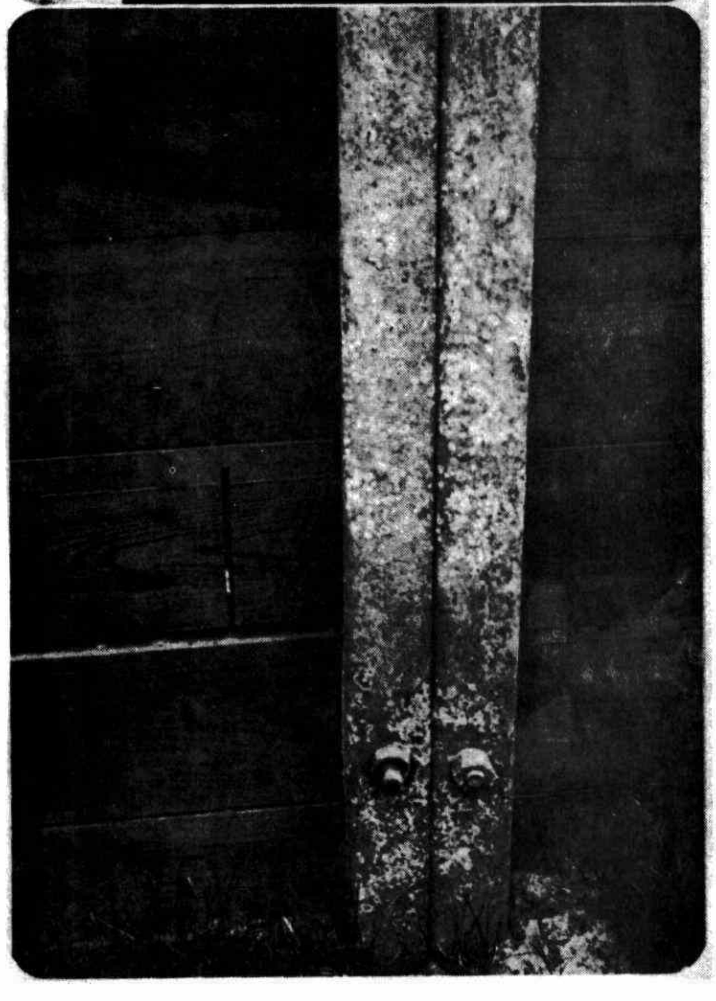
The contract design specified that the planks would rest on top of but not be a part of the concrete footing. The photograph below reveals this is not so.



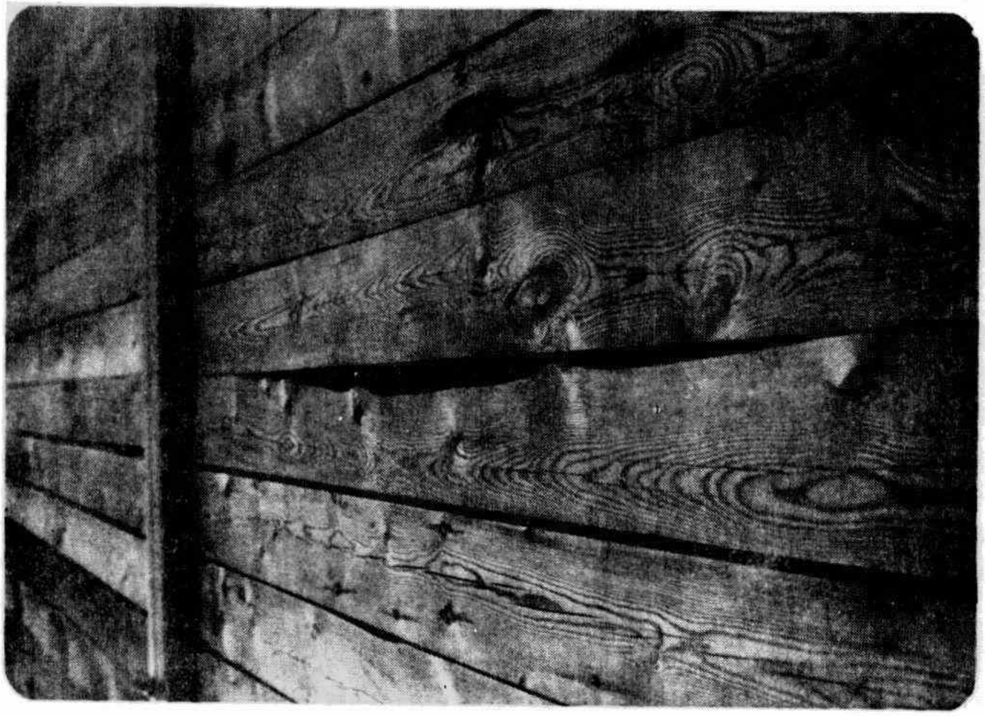
A location where a gap resulting in a noise leak requires remedial work is at the ends of the structures as illustrated. (Right).



Evidence of initial corrosion was revealed on a few posts. This was an isolated instance on this project. Similar posts as part of the privacy fence erected in 1974 have not revealed such extent of corrosion



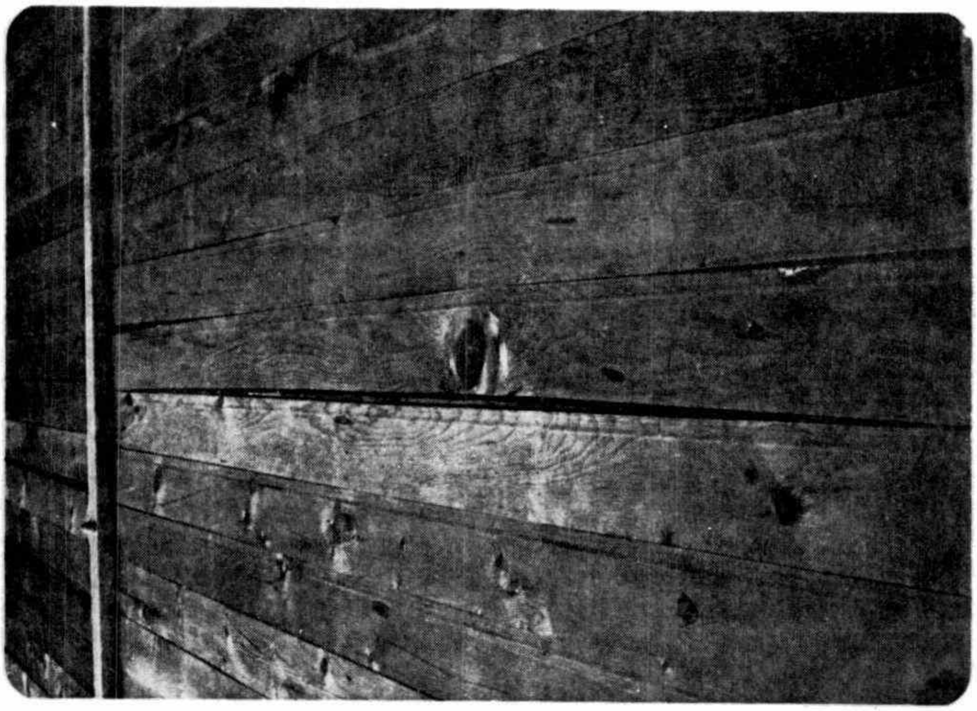
The specification limits "wane" to less than that shown.



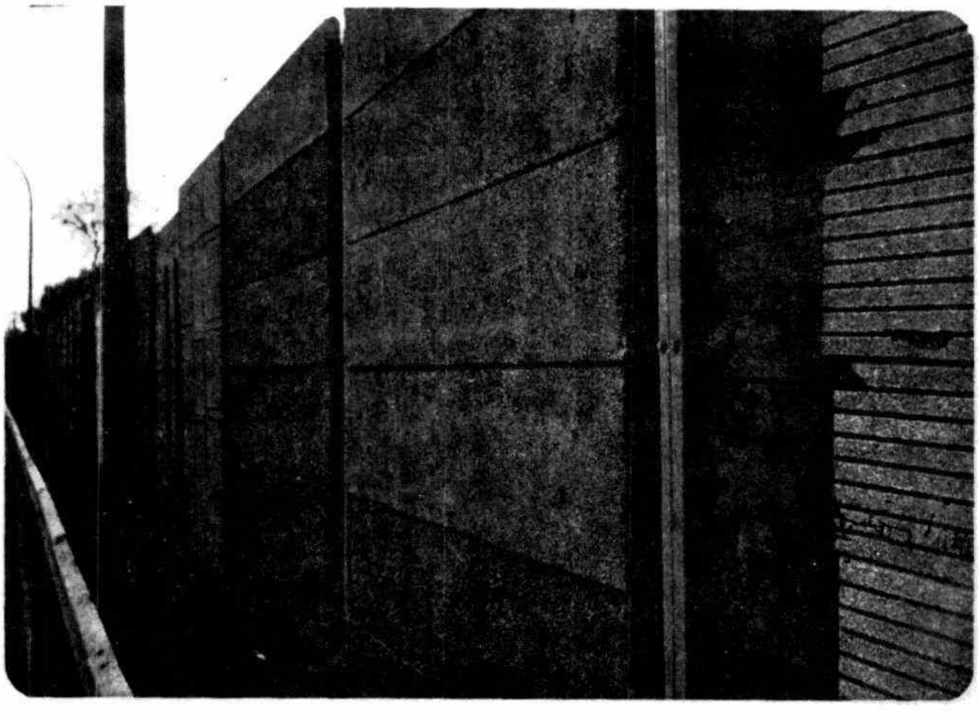
Some planking should have been replaced with more acceptable timber although this is not a frequent occurence.

A44

Planking with knots such as illustrated are more prone to distortion and should be rejected initially.



The timber barrier was utilized over the Winter of 1977-78, experimentally, for durability tests of various sound absorbant type panels. Of many materials tested, Durisol panels provided a negligible deterioration.



District Maintenance forces of the Ministry performed the necessary adjustments to restore the barrier to its original condition by removing the bolts, pulling the planking downwards and re-anchoring the bolts. A further review following the next Winter of 1978-79 has determined that the barrier is acceptable in its restored condition without further leaks or distortion.

Noise measurements following barrier adjustment indicate a substantial improvement of approximately 3 dB(A), thereby restoring the barrier to its anticipated acoustic performance.

In the Fall of 1978, a barrier extension was carried out with the use of 2" nominal timber planking in an effort to determine the impact of snow ploughing operations. Although the Winter of 1978-79 provided only a limited amount of snow, there was no concern with the lesser thickness of wood.

Due in part, to the initial distortion of planking, the inherent colour of pressure treated wood, experimental and temporary sound absorbant panels affixed to the barrier, the lack of visual "relief" and the relatively high cost of material, alternate barrier materials are being considered in order to provide improvements in barrier aesthetics for future barriers on the Ottawa Queensway.

MTC CURRENT DESIGN STANDARDS PRACTICE

The Ministry's current preference for an optimum choice of barrier design is the vertical steel barrier based upon considerations of financial analysis and assessment for materials such as steel, timber and concrete, short and long term performance including maintenance, appraisal of barrier aesthetics and the desire for initial low cost barriers. This does not preclude the choice of alternate barrier materials to suit a particular site nor inhibit the continual barrier development and refinements necessary to achieve appropriate cost effective and aesthetic barriers.

Colour options are available for steel barriers. However, the choice is limited with eleven colours only in 'Vinytop'. Vinytop is a polyvinyl chloride coating produced by the Steel Company of Canada and deemed to be the most effective coating for providing film flexibility while maintaining resistance to salt spray, abrasion, etc.

Colours recently chosen for barriers are Pacific Turquoise and more recently (yet to be constructed) light grey.

The thickness of metal for steel barriers based on a cost effective performance is 20 gauge. (Ref. 10).

REFERENCES

1. Ministry of Transportation and Communications "Noise Barrier Evaluation and Alternatives for Highway Noise Control" by M.D. Harmelink and J.J. Hajek - Report No. RR180 September 1972

2. Ministry of Transportation and Communications "Privacy Fence Evaluation Highway 401" Warden Avenue to Victoria Park Avenue - August 1976

3. Ministry of Transportation and Communications "Ontario Highway Noise Prediction Method" by J. J. Hajek - RR197 January 1975

4. Ministry of Transportation and Communications "An L_{eq} Traffic Noise Prediction Method" by J.J. Hajek

5. Ministry of Transportation and Communications "Highway Noise Barrier Location for Maximum Benefit/Cost" by C. Andrew and D.N. May - Report No. 78-AC-03

6. Ministry of Transportation and Communications "Analysis of Noise Barriers Impact on Dissatisfaction with Freeway Annoyances" by B. Deslauriers and P. Gorys

7. Ministry of Transportation and Communications "Ambient Noise Level Measurements in the Vicinity of a Proposed Noise Barrier, Queensway, Ottawa, by D.J. Godard - Report No. 76-TlL-21, January 1977

8. Ministry of Transportation and Communications "Noise Barrier Attenuation - Highway 417 North Side Melrose Avenue to Loretta Avenue, Ottawa" by D.N. May - Report No. 78-AC-13, December 1978

9. Ministry of Transportation and Communications "Noise Barrier Attenuation - Highway 401 South Side, Dixon Road to Kipling Avenue, Toronto by D.N. May - Report No. 77-AC-09, November 1977

10. Ministry of Transportation and Communications "The Optimum Weight of Highway Noise Barriers" by D.N. May - Report No. 78-AC-14, December 1978, presented to TRB-FHWA Conference on Highway Traffic Noise Mitigation, Los Angeles, California, December 11-15, 1978, and included in proceedings.

APPENDIX - VERBAL PRESENTATION BY J.R. WEAR.

MTC NOISE BARRIERS

Introduction

In the next 20 minutes I will quickly and briefly outline the Ontario Ministry of Transportation and Communications experimentation, experience and design of barriers to diminish highway noise for residents living adjacent to existing freeways.

Background

The Ministry undertook an extensive reconstruction program for the McDonald Cartier Freeway, Hwy 401 through Metropolitan Toronto in the 1960s to widen an existing 4-lane highway to a 12-and 16-lane freeway. This work was not without perceived consequence to local residents giving rise to increased visual and noise intrusion.

In order to provide privacy and possible relief from dust, fumes and noise, extensive plantings of Austrian Pine were placed at the right-of-way limit in existing residential areas.

In conjunction with the tree planting, a demonstration project noise (S-1) barrier was installed in early 1971. Experience with noise barriers and design was limited then and although variations were provided in use of lightweight and conventional concrete walls mounted separately and on berms, (S-2) the performance was less than gratifying for both Ministry and residents. An average 3 dB(A) attenuation was achieved with an expense of approximately $200.00 per linear metre or $65.00 plf to achieve a barrier height averaging 3 m or 10' above pavement.

(S-3) The barrier was built at more or less a constant height above pavement but due to highway vertical alighment at the location, a sag condition, an optimum design was not realized or deemed possible at that time.

(S-4) Metropolitan Toronto commenced experimentation also but the same disappointing results were obtained for noise attenuation. The Porex panel concrete barrier shown although 3.5 m or 12' high was too short and did not envelop the residential area to be protected.

(S-5) This barrier was not without problem in maintaining satisfactory alignments and is subject to stress and deterioration. (S-6)

(S-7) Additional Metro Toronto barriers were installed using plywood and aluminum materials for walls as well as gabions as illustrated. The Gabion wall although not sufficiently high enough is probably (S-8) the first sound absorbant barrier to be erected in Ontario. Results were inadequate, costs were high and Metro ceased experimentation with noise barrier walls.

(S-9) Although the Ministry continued the tree planting program which was providing visual relief for residents, a new approach was adopted by the Ministry in providing, experimentally, a visual barrier called a privacy fence. The barrier shown, having a series of vertical steel panels of 24 and 26 gauge varying in height from 2'5 to 3'5 m or 8 to 10' was able to provide 5 dB(A) and greater attenuation. This was also without sealing a 2" gap at the bottom of the barrier. Costs of such a barrier were less than $120.00 lm or $40.00 plf. Social surveys were conducted before and following barrier erection to reveal that residents were satisfied.

A renewed enthusiasm was generated of being able to provide effective noise barriers as determined from field results and computer prediction techniques. (S-10) The experimentation also demonstrated that a structure mounting could provide barrier continuity. (S-11) Transition treatment is also suitable to maintain control of alignment and grade. (S-12). However, experience reveals a great deal that although one problem is partially alleviated, yet another occurs. In this case the close proximity of the barrier wall to the travelled portion of pavement has resulted in damage due to snow removal operations. The latest acoustic standard adopted by the Ministry requires a heavier gauge. (S-13) At the time of providing the initial Ministry privacy fence a developer within the same area chose another alternative for a barrier material. (S-14) The California Redwood was chosen for aesthetic reasons but the cost is high. (S-15) Here a successful barrier has been installed although not intended as a noise barrier. (S-16) The design however does lend itself to adaption as a noise barrier providing (S-17) noise leaks are eliminated.

Due to ever-increasing concern by residents with noise emanating from the freeway the Ministry could not consider the erection of privacy fences per se and that too high an investment cost is required.

As a result of success with the Privacy fence and anticipated benefits from barriers to be erected in other locations, the Ontario Government in February of 1977 announced a program to provide, where feasible, barriers on freeways through existing residential areas wherever substantial attenuation could be achieved and at a reasonable cost. A budget was established to retrofit existing freeways and expenditure would approximate one million dollars per year.

Audio Visual Presentation

I would like you now to hear an audio visual presentation that is used as an introduction on the subject of noise for residents reviewing and providing input for design of barriers at public information centres.

MTC Noise Policy and Barriers

(S-18) Second generation noise barriers were commenced in 1977 with design based on achieving a 5 dB(A) avg minimum attenuation measured 1'5 m above ground in the middle of the recreational area - ten (10) dB(A) attenuation is difficult to attain and 15 dB(A) is not readily attainable of adjacent residences. A cost effective optimum barrier height was established at 4 m with higher or lower barriers permitted depending on the requirements for each site. Barrier satisfaction is such that the higher the existing noise the greater is the requirement for higher noise attenuation.

Generally, an increase in height of 1 m results in approximately 1.5 dB(A) additional attenuation. In 1977 over 160 candidate sites were considered and 106 sites were prioritized using computer prediction techniques with existing noise level, number of residences affected, the amount of attenuation that could be provided for each residence and the construction costs of a barrier and extras to provide the attenuation. This list is subject to change and updating in the Fall of each year as required. Overall, a potential $20 million plus for a retrofit program could be possible and would involve 100 km or 60 miles of barrier.

The barrier illustrated here is of experimental tongue and groove horizontal timber planking of pressure treated jackpine located on the Ottawa Queensway and constructed in 1977. The height is 3 m or 10' and is mounted on the shoulder at a very high embankment. The design is similar to that shown in previous slides. Various wood options were permitted in order to obtain an economical installation. Costs however were approximately $174.00 /metre or $54.00 plf. (S-19) A 75 mm or 3" planking thickness was chosen for the shoulder installation to offset structural loading due to ploughing operations and the heavy snow falls in the Ottawa area. A portion of 50 mm or 2" planking has also been installed for comparison purposes. Acoustically, material of 1.5 psf or less than 50 mm nominal thickness would be adequate. Structurally, a 20 psf wind loading is the basis for current designs. (S-20) A structure mounting is also illustrated, the cost of which almost doubles that of an in ground mounting. (S-21) Difficulties were initially encountered with distortions and gaps developing between planking. The paper prepared for RTAC 1979 entitled Design of Noise Barriers gives an insight into various difficulties and the solutions. Once the leaks were eliminated, the barrier performance increased from 3 dB(A) attenuation to 6 dB(A) as was intended. (S-22) At the same time, a 4 m steel barrier was erected in Toronto's west end along hwy 401 which, at a cost of approximately $120.00 per metre or $40.00 plf produced 7 dB(A) of attenuation. This barrier as is the case with all Ministry barriers was tendered and alternatives of vertical steel and concrete were included in the contract. The separation and safety for traffic of at least 1 m is provided by steel beam guide, rail or concrete jersey barrier. Where terrain does not vary by more than 4' the noise barrier should be located close to the receiver for increased noise attenuation effectiveness and greater safety. Ministry experience with this barrier has revealed a glare particularly when wet that is now alleviated for newer barriers with a change in coating from a silicone alkyd paint to a poly vinyl called Vinytop. This newer coating virtually eliminates the previous problem of tenside cracks developing at bends during the profiling process. The steel is supplied in coil form previously coated for reasons of economy. Residents are not entirely satisfied with the attenuation provided by this barrier due to the very high 75 dB(A) Leq+ existing noise level. Although social surveys have attempted to distinguish separately the noise from airplanes almost directly overhead for runway 32 right to Toronto International, the conditions are not conducive for the success of a noise barrier.

(S-23) Earth berms were placed on hwy 404 in Metropolitan Toronto as part of the construction of a freeway extension for the Don Valley Parkway. Material for the most part came from a surplus to the fill requirements for the project. (S-24) The 3 m berms are pleasing, economical and would provide better attenuation than a comparable height of a thin barrier wall. (S-25) Extensive landscaping complements the berms although there is an ever present maintenance demand to control weeds. Desirably the property limit should coincide with the top of berm to facilitate maintenance.

(S-26) A lengthy and experimental noise barrier was constructed in 1978 on hwy 401 using on the traffic side horizontal Durisol panels, of 2.5" thick cemented wood chips with a 3/4" reinforced concrete backing. The Durisol material has a sound absorbancy coefficient exceeding 0.7 thereby providing sound absorbancy whereas most metal wood and concrete barriers are reflective. The sound absorbancy however provides negligible benefit to the residents behind the barrier. Sound absorbancy, however, is a definite asset where closely spaced parallel and opposing barriers are required.

(S-27) This barrier of 4 m in height has provided approximately 8 dB(A) avg attenuation for the first row residences and is acceptable to the community. Existing noise levels approximate 72-76 dB(A) Leq. (S-28) Barrier costs are $200.00 per metre or $65.00 plf and would be as low a price as could be obtained for virtually most concrete barriers. (S-29) Landscaping should be added to complement and tie-down the barrier where possible. The Durisol material is desirable and would be subject to deterioration only if placed in a saturated condition, such as a saturated condition, such as standing water. If necessary, the lower panel could be reversed or replaced with a solid concrete panel.

(S-30) The exposure on the resident side of the Durisol barrier is typically a grey uniform concrete colour for which many residents have expressed a preference for another colour.

(S-31) A recently constructed barrier on hwy 401 at Yonge Street is the result of competitive bidding between vertical, horizontal steel and Durisol material. The panel profile is the most economical available using the standard 20 gauge material required for satisfactory acoustical performance. Barrier cost would approximate $150.00 per metre or $45.00 plf for the 4 m barrier height.

(S-32) Access for maintenance was required as shown. Barrier performance however is diminished and such openings should be avoided if at all possible.

(S-33) A mounting on a retaining wall on the opposing side of the highway shown has provided little benefit for residents on the first floor of apartments 3-5 dB(A). The second floor residents however have far greater benefit from such a barrier. This barrier was limited in height to less than 3 m or 8' due to stress in the wall to which it is attached. For level terrain, only the first floor residents would be considered to benefit from a noise barrier and with high level dwellings a noise barrier is an impractical arrangement.

(S-34) The privacy side of the horizontal barrier is revealed with visual relief provided by posts for the static view of barriers. A similar barrier of 4800 m or 16,000 lf was constructed as part of the widening of hwy 401 through Oshawa at a cost of $80.00 linear metre or $30.00 plf. Ideal circumstances however provided economy.

To conclude, the Ministry has gained considerable experience from barriers erected by the Ministry and others and as a preference a vertical steel barrier wall as being aesthetic, reasonably economic and cost-effective. This will ensure that as many barriers can be provided within the constraints of a very limited budget for noise abatement on freeways. Various colour options are featured in the latest barrier designs although the choice is quite limited. e.g., light grey, medium brown in addition to Pacific Turquoise. Varying materials and deisgn make the stockpiling of materials more difficult with the public and private sectors for material improvements and cost-effective designs. The Ministry is encouraged with recent results from modelling and experimental on site testing of a T-top shaped barrier deisgn. There is however, considerable knowledge and advancement necessary in the state of the art for barrier designs particularly where parallel and closely spaced barriers are required. Recently, public complaints express the need to have opposing barriers constructed at the same time. Overall, the Ministry of Transportation and Communications within economic and development constraints considers it is responsive to the needs of the public in providing where it is most required cost effective barriers to diminish the problem of noise from freeways.

1979 09 25

Transportation Noise Control in Land Use Planning

by

J. Manuel

Environment Ontario

The paper outlines the development of the Ontario government approach to planning with respect to transportation noise. Since 1974, the Ontario Ministry of the Environment has routinely examined all new projects pursuant to the existing legislation. In 5 years more than 2000 land use applications, representing a small fraction of the total, have been specifically examined because potential noise impacts have been recognised or are anticipated.

The paper traces the genesis of applicable Ontario policies and guidelines and compares them with HUD and other criteria. It describes the approval procedures, assessment techniques and measures taken to educate industry and the public in the noise control planning aspects of new land uses.

Presented at NOISEXPO 1979 in Chicago, Ill.

TRANSPORTATION NOISE CONTROL IN LAND USE PLANNING

by

J. MANUEL

ONTARIO MINISTRY OF THE ENVIRONMENT

TORONTO, CANADA   M4Y 1P5

Since 1974, the Ontario Ministry of the Environment has routinel examined all new projects for noise impact pursuant to the existing legislation. In 5 years more than 2000 new land use applications, representing a small fraction of the total, and a lesser number of industrial and commercial project applications have specifically been examined because potential noise impacts have been recognised or were expected.

It is interesting to trace the genesis of the Ontario noise control program as it evolved from the time the Ministry of the Environment was reorganised in April 1974. It was then that the Noise Pollution Control Section was established as a separate technic unit within the Pollution Control Branch of the Ministry. Prior to April 1974, noise control was a responsibility of the Air Management Branch and before that the Public Health Department of the Ministry of Health responded to noise complaints lodged by the public.

The rapid advances made over the past 5 years go hand in hand with the phenomenal technological developments in instrumentation and the knowledge explosion. For example, predictive techniques using the equivalent sound level were used for the first time in Ontario in November 1974 to assess, on behalf of the federal governm the probable noise impact of a new commuter service on an already existing freight train line. The Ontario community monitoring capability expanded enormously when new auto ranging, cassette storage, digital sound analysis systems were purchased in February 1975 from Digital Acoustics Inc. Overnight it made multi-day monitoring over a 118 dB dynamic range with up to 8 samples/second a simple task. The data stored in cassettes was readily available in almost any format required by the acoustical analyst. This advance in 1975 brought about establishment of a new government/developer rapport with respect to noise. Up to this time the Noise Assessment Guidelines prepared for HUD by Schultz[1] in May 1972 were being used to define acceptable limits for new land uses. However, with the acquisition of second generation digital sound level monitors, serious new consideration was given to improving the criteria by laying down more precise limits.[2] These limits were supported by the work of Dixit,[3] by Gidamy and Hemingway[4], by Hemingway and Kramer[5] and by Kramer[6] and confirmed in some measure by work done by the National Research Council of Canada,[7] on behalf of the Central Mortgage & Housing Corp.

The sound level limits adopted in 1975 for land use approvals are given in Figure 1. Figure 2 compares the "Ontario original design cumulative A-Weighted Sound Level distribution superimposed on the ranges suggested for HUD" (Ref.1)

Subsequent use of these criteria in many practical situations convinced the Ministry staff that it could safely reduce percentile data required of project proponents to one single percentile noise descriptor. The descriptor, other than the equivalent sound level (Leq) now specified as the Ontario criteria, is the 50th percentile (L50) as illustrated in Figure 3[8]. Further refinement of the land use noise criteria has occurred since 1975 and these refinements are discussed elsewhere.[9]

The knowledge explosion within the Ministry was further spurred by the need to develop the training manuals required to train municipal noise control officers and land use planning approving authorities. These manuals were planned, developed and written by Ministry staff under extreme pressure to meet planned deadlines while continuing to carry out the normal routine work load. A succession of supplementary reports and government policy also appeared in quick succession thus expanding public knowledge and awareness in the noise domain. These publications or announcements are listed in order of appearance:

- Land use criteria, preliminary, March 1975
- Model Municipal Noise Control By-Law, March 1975
- Environmental Acoustics Technology I, May 1975
- Environmental Acoustics Technology II, August 1975
- Environmental Acoustics Technology III, February 1976
- Model Municipal Noise Control By-Law, revised, May 1976
- Community (3) Noise Levels Report & data, June 1976
- Report on Noise Impact, New Townsend Community, September 19
- Acoustics Technology in Land Use Planning, Vol. II, December
- * Ontario policy on barriers for existing freeways, February 19
- Acoustics Technology in Land Use Planning, Vol. I, April 1977
- Railyard Noise Symposium (CP Rail joint sponsor), July 1977
- * Ontario policy on land use near airports, March 1978
- Model Municipal Noise Control By-Law, Final Report, August 19
- *Ontario policy on new land uses near freeways.

* These policies were announced by other Ontario Ministries.

In addition to the publications and policy announcements related to transportation noise listed above, many internal reports were also developed on diverse topics such as the design of acoustical shrouds for air conditioners; blasting guidelines; impulse studies on drop hammer forges, presses, bird scaring guns; gun clubs and others. Work has recently been completed on an intensive rail yard analytical study and the results have been communicated to the EPA at their request to assist in developing U.S. railway noise standards.

In conclusion, the planning over the past 5 years has been oriented to encouraging local authority to take ever increasing responsibility for noise control actions in the community. This has largely been accomplished by ammending the empowering legislation, providing the model by-law, the training manuals and extensive traini programs. Severe budgetry constraints on the provincial authority will no longer permit personal one-to-one investigation of private noise complaints which, in any event, are more easily handled by the local authority. Noise complaints due to air-conditioners, barking dogs and noisy motorcycles are examples of local problems best handled locally.

Cost/benefit considerations logically demand that the resources of the Ministry be devoted to the greater problem of preserving the environment in future developments housing many thousands, through careful assessment and planning to minimise noise impact from road and rail traffic.

L_N	Limit dBA
L_{90}	48
L_{50}	52
L_{10}	60
L_1	67
L_{eq}	55

Figure 1:

L_N and L_{eq} Sound Level Limits Derived From HUD TE/NA 172(Outdoor)

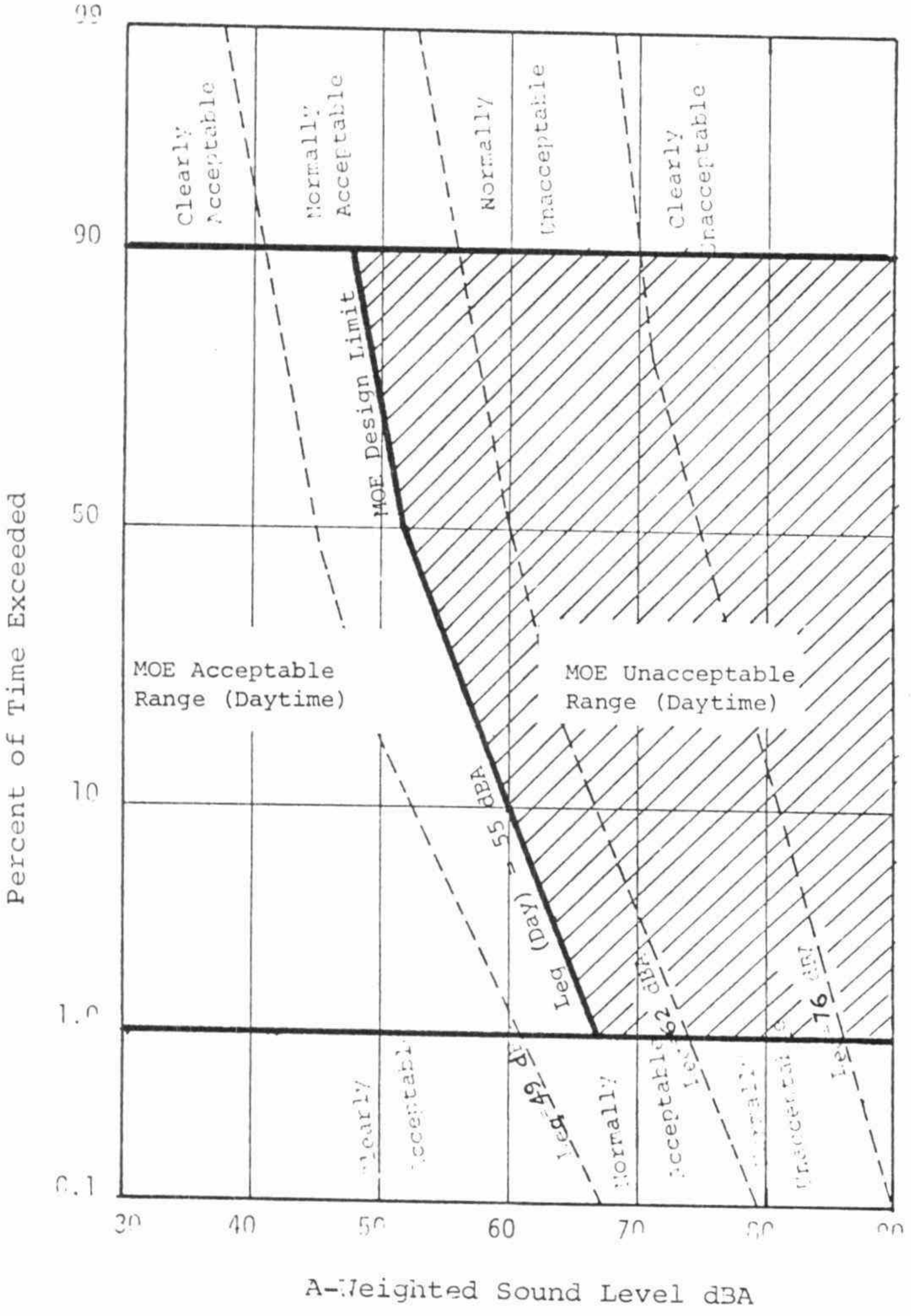


Figure 2: M.O.E. Original "Design Cumulative A-Weighted Sound Level Distribution" Superimposed on the Ranges Suggested for U.S. HUD (Ref.1).

Table 131-1
Indoor Sound Level Limits

Type of Space	Equivalent Sound Level (L_{eq}), dBA
Bedrooms, sleeping quarters, hospitals, etc. (Time period 23 00 - 07 00)	40
Living rooms, hotels, motels, etc. (Time period 07 00 - 23 00)	45
Individual or semi-private offices, small conference rooms, reading rooms, classrooms, etc. (Time period 07 00 - 23 00)	45
General offices, reception areas, retail shops and stores, etc. (Time period 07 00 - 23 00)	50

Table 131-2
Sound Level Limits for Outdoor
Recreational Areas (07 00 - 23 00)

Sound Descriptor for the Entire Period	Sound Level Limit, dBA
L_{50}	52
L_{eq}	55

Table 131-3
Sound Level Limits for Outdoor
Areas (23 00 - 07 00)

Sound Descriptor for the Entire Period	Sound Level Limit, dBA
L_{50}	47
L_{eq}	50

Figure 3: Ontario Land Use Planning Criteria

References:

1. T. J. Schultz,B3N Inc.Mass."HUD Report No TE/NA 172, BBN No.2005SR." May 1972.
2. Memorandum J. Manuel to H. Gidamy, March 1975 Noise Pollution Control Section, Environment Ontario.
3. A.K. Dixit, Environment Ontario "Community Noise Levels in Kingston, North Bay & Sault Ste. Marie", June 1976.
4. H. Gidamy & J. R. Hemingway, Environment Ontario. "Setting & Refining Sound Level Limits for New Residential Development" C.A.A., October 1977.
5. J. R. Hemingway & F. Krammer, Environment Ontario, "An Investigation of the Human Response to Highway, Arterial and Railway Noise" C.A.A., October 1977.
6. F. Krammer, Environment Ontario, "Predicting Human Reaction to Community Noise", Human Factors Association of Canada, May 1978.
7. CMHC "Road & Railway Noise, Effects on Housing, " July 1978.
8. Model Municipal Noise Control By-Law, Final Report, NPC-131, Environment Ontario, August 1978.
9. Ontario policy on new land uses near freeways. Pending.

ENVIRONMENTAL NOISE CONTROL IN ONTARIO

BY

J. MANUEL, P. Eng.

The Ontario Ministry of the Environment has, over the past 6 years, developed a broad environmental noise control program that covers regulation development, standards setting, enforcement, training and the assessment of all new land uses and new projects. To carry out its mandate, a number to training texts have been published as well as a variety of technical publications supporting a Model Municipal Noise Control By-Law. This by-law may be adopted, in whole or in part, by local government depending on the need and desire to control noise in the community.

Aspects of the existing environmental noise control program are discussed as well as the direction of future planned activty.

Presented at NOISEXPO 1979 in Chicago, Ill.

ENVIRONMENTAL NOISE CONTROL IN ONTARIO

by

J. Manuel

ONTARIO MINISTRY OF THE ENVIRONMENT

TORONTO, CANADA M4V 1P5

The Ontario Environmental Protection Act, 1971, provides for the protection and conservation of the natural environment which includes the air, land and water or any combination or part thereof. Under the legislation, no person may emit or discharge any contaminant in excess of that prescribed by the regulations. A contaminant for the purposes of the legislation means any solid, liquid, gas, odour, heat, sound, vibration, radiation or combination of any of these resulting from the activities of man. Furthermore, Regulation 15, Section 6 of the Act prohibits the emission of any air contaminant that may:

1) cause discomfort to persons;
2) cause loss of enjoyment of normal use of property;
3) interfere with normal conduct of business; or
4) cause damage to property.

In addition to this regulation and other noise related provisions in the Act, Section 95a amended in October 1975, permits municipalities to pass by-laws to:

5) regulate or prohibit the emission of sound or vibration;
6) provide for the licensing of persons, equipment and premises;

7) prescribe maximum permissable levels of sound and vibration that may be emitted;

8) prescribe procedures for determining levels of sound and vibration.

In order to assist municipalities and, at the same time, preserv a uniform standard, a model by-law was first published in March 1975 and revised in May 1976. The final report of the Model Municipal Noise Control By-Law was issued in August 1978. The model by-law has, to date, been used in preparing about 20 local by-laws which, after adoption by Council, have been approved by the Minister of the Environment. A similar number are concurrently being prepared by various communities across the province. The by-laws in place now afford noise control protection to about 28.0% of all the population of the province of Ontario. A substantially greater percentage of the total urban population is expected to be included by the end of the decade, under this legislation.

The model by-law is unique in several respects. Firstly, taken as a whole, it probably is the most comprehensive noise control legislation available anywhere for adoption by the local authority. Flexibility is built in by permitting municipalities to adopt all or any part of the model by-law depending on the need, local conditio and the desire to control noise in the community. Further flexibilit is provided by permitting almost any amendment to the subjective nois control provisions contained in the model by-law. Secondly, the quantitative noise controls provide for the needs of larger urban communities.

The range of quantitative controls covers most of the every day problems and many special industrial activities such as impulsive noise, blasting, truck and construction equipment noise. To make this possible, instrument standards and specific measurement procedure standards had to be written where national or international standards were non-existant.

The technical documents supporting the model by-law are known as Noise Pollution Control Publications (NPC) and these include the standards and procedures mentioned above as well as a selection of guidelines (NPC 131 to NPC 134) that are provided for the guidance of urban and rural authorities in land use planning and zoning; issuance of construction permits; new industrial and commercial project approval; the development of public works; and the acquisition of municipal mechanical equipment. The technical publications and guidelines are also used by the private sector and their consultants in making applications for government approval.

It may be useful to list here a few of the specific features of the model by-law. To begin with, equivalent sound levels below 40 dBA are excluded from the by-law. As mentioned above the by-law includes:

a) Impulsive noise standards;

b) Blasting standards for mines and quarries;

c) Heavy diesel engine truck standards;

d) Traffic noise prediction tables;

e) Standards for air conditioners and power tools including construction equipment;

f) Instrument standards for:

- General purpose sound level meters,
- Impulse sound level meters,
- Peak pressure level detectors,
- Integrating sound level meters, for low and high crest fac
- Vibration velocity detectors, and
- acoustic calibrators.

When this program was launched in the Fall of 1974 it was announced that the Ministry of the Environment would also provide noise control training to designated municipal by-law enforcement officers, police and Ministry staff. To accomplish this program a series of training manuals were developed and printed for public use. A list of available publications is provided in APPENDIX I while the training curriculum is given in APPENDIX II The training program normally spans the winter months of each year. Over the four year period ending March 1979, more than 800 trainee-weeks of acoustics training, seminars, and workshops, both theoretical and practical, have been provided to municipal, provincial and federal government staff, engineers, architects, lawyers, planners and consultants.

References:

1) J.Manuel, Environment Ontario"Ontario Model Municipal Noise Control By-Law" Inter-Noise'75, Sendai, Japan, 1975

2) J.Manuel, Environment Ontario"Ontario Model Municipal Noise Control By-Law" Inter-Noise'76, Washington D.C., 1976

APPENDIX I

Publications of the Ontario Ministry of the Environment

- Model Municipal Noise Control By-Law and Noise Pollution Control Publications (NPC-100 to NPC-135 Inclusive)
- Training Manuals
  - Environmental Acoustics Technology I to IV
  - Acoustics Technology in Land-Use Planning, Volumes I and II

Publications of the Ontario Ministry of Transportation & Communications

- Traffic Volumes on the King's Highway and Secondary Highways (Revised Annually)

These Publications are obtainable from:

Ontario Government Bookstore
880 Bay Street
Toronto, Canada
M7A 1N8 Tel. (416) 965-2054

Also recommended for land use planning are publications of the Central Mortgage and Housing Corporation of Canada

- Site Planning Criteria
- Road and Rail Noise, Effects on Housing
- New Housing and Airport Noise

APPENDIX II

Publication NPC-135

Certificate

1. Scope

This Publication sets out the minimum requirements for granting a Certificate of Competency in Environmental Acoustics Technology.

2. Certification

A Certificate of the specified class shall be issued by the Minister to any person who has satisfactorily completed the following training courses in Environmental Acoustics Technology, offered by the Ministry:

Certificate Class	Training Courses
1	Acoustics I and II
2	Acoustics I, II, and III
3	Acoustics I, II, III and IV

6. Curriculum

Acoustics I

Introductory Acoustic Theory; Law; Handling of Complaints; Use of simple sound level meter, octave band analyser and calibration techniques; Measurement of traffic noise and industrial noise; Procedures; Audiometry; Personal hearing test; Examination.

Acoustics II

Review of Acoustics 1; Theory; Law; Complaint investigations; National and International Standards; Use of 1/3 octave analyser; Tape recorder; Impulse sound level meter; Introduction to L_{eq}; Field work; Examination.

Acoustics III

Review of Acoustics II; Theory; Law; Stop orders; Control orders; Provincial officer's report; Prosecutions; Graphic analyser; Statistical analyser; Sound descriptors, percentiles, cumulative and statistical distribution; Vibration analysis; Stationary source noise analysis; Laboratory; Field work; Examination.

Acoustics IV

Review of Acoustics III; Theory; Law; Use of digital monitors; Off-road and road side traffic measurements; Field investigation and reports; Technical Publications; Implementation of a Noise By-Law; Advanced procedures; Selection of instrumentation; Examination.

7. Audiometric Test

Candidates for their first Certificate and for any reissue of a Certificate shall submit to a binaural audiometric test. Test results shall in every case be disclosed to the candidate and to the sponsoring employer.

INSTITUTE OF TRANSPORTATION ENGINEERS

1979 ANNUAL MEETING, TORONTO

SEPTEMBER 23, 1979.

TRANSPORTATION NOISE

by

J.Manuel P.Eng MEIC

In 1974 the Ontario Ministry of the Environment investigated the probable increase in sound levels due to the introduction of a new GO Transit commuter service utilising an already existing freight rail line. To carry out this assignment, a prediction technique involving the energy equivalent sound level was used for the first time in Ontario. This noise descriptor was chosen because it lends itself to the assessment of intrusive transportation noise while correlating well with human annoyance response.

The paper traces the genesis of Ontario noise policies and guidelines and discusses the assessment and training techniques developed over the past five years by the Noise Pollution Control Section and others in meeting environmental noise control objectives in Ontario.

This paper was originally presented
at the 1979 meeting of the
Institute of Transportation Engineers
in Toronto, Canada.

INTRODUCTION:

This paper traces the genesis of Ontario noise policies and guidelines and discusses the assessment and training techniques developed over the past five years by the Noise Pollution Control Section and others in meeting environmental noise control objectives in the Province of Ontario.

In the Fall of 1974 the Ontario Ministry of the Environment investigated the probable increase in sound levels due to the introduction of a new GO Transit commuter service utilising an already existing freight rail line. To carry out this assignment, a prediction technique involving the energy equivalent sound level (L_{eq}) was used for the first time in Ontario. This noise descriptor was chosen because it lends itself to the assessment of intrusive transportation noise while correlating well with human annoyance response. This project was our introduction to a new approach to noise control and to the new solid state chip technology that has revolutionized long term acoustical monitoring of transportation noise.

Prior to this change over to the use of the equivalent sound level as the primary noise descriptor, a six-point noise control program had been established for implementation throughout Ontario. The phases of this program were as follows:

(a) prepare and implement a regulation to control noise from roadway vehicles;
(b) prepare and implement a regulation to control noise from stationary sources;
(c) establish ambient noise level objectives;
(d) develop a model municipal by-law for use by municipalities;
(e) prepare and implement a regulation to control noise from recreational devices;
(f) develop expertise and guidelines to be able to comment on land use changes as they are affected by noise.

To implement this program, the initial emphasis had been given to those areas that had resulted in the majority of noise complaints received by the Ministry. Roadway vehicles and stationary sources accounted for 80 per cent of all complaints; hence, regulations to control noises from these two sources were given priority. The Noise Pollution Control Section produced a draft regulation to control the noise from roadway vehicles and implemented a field trial of the regulation in Hamilton in March, 1974. In preparing this regulation, approximately 1,000 measurements of many different types of vehicles were made.

The second regulation, to control stationary source noise, was also in the final stages of preparation and was to be field tested during the summer of 1974. To gather data for the drafting of this regulation, inspectors investigated noise complaints in both Toronto and Hamilton. During the 1974 approximately 350 complaints were received of which 130 were investigated. It is interesting to note that although the regulation was at that time only in the draft stage, 60 of the complaints were resolved through the efforts of the Noise Pollution Control Section staff.

In addition to preparing regulations to control noise, community studies were undertaken in London, Woodstock, Kingston, North Bay and Sault Ste. Marie, These studies were conducted to provide an understanding of noise levels in communities, and at the same time, to provide information for the establishment of ambient noise level objectives for the Province of Ontario.

NOISE PROGRAM GOALS:

It is interesting to trace the genesis of the Ontario noise control program as it has evolved from the time the Ministry of the Environment was reorganized in April 1974. It was then that the Noise Pollution Control Section was established as a separate technical unit within the Pollution Control Branch of the Ministry. Prior to April 1974, noise control was a responsibility of the Air Management Branch and before tha the Public Health Department of the Ministry of Health responded to noise complaints lodged by the public.

The Ontario Ministry of the Environment has, over the past six years, developed a broad, source oriented and receiver oriented, environmental noise control program that covers regulation development, standards setting, the assessment of new land uses and new projects, enforcement and training.

Since 1974, the Ontario Ministry of the Environment has routinely examined new projects for noise impact, pursuant to the existing legislation. In five years more than two thousand new land use applications, representing a small fraction of the total, and a lesser number of industrial and commerical project applications have specifically been examined because potential noise impacts have been recognized or were expected. During this time over 2000 noise complaints have been investigated and many of these resolved to the satisfaction of the complainants.

Goals of the Ministry of the Environment

1. "To ensure proper control over the emission of contaminants into the natural environment for the purpose of achieving and or maintaining predetermined standards of environmental quality."

2. "To ensure that proposed programs, projects, policies and legislation in or affecting Ontario incorporate the necessary environmental safeguards through direct involvement in the co-ordination and development of a provincial land use plan."

3. "To develop specialized techniques for the restoration and enhancement of environmental quality."

Goals of the Pollution Control Branch

"To assess the current and potential effects of various pollutants and develop abatement strategies, plans and support procedures."

Goals of the Noise Pollution Control Section

"To investigate sources of sound and vibration, evaluate their impact on the environment and develop plans, policies and programs for their control within a Federal/Provincial/Municipal framework."

NOISE CONTROL IN LAND USE PLANNING

There is a growing concern for the way that we use land. Planners, engineers, environmentalists and legislators are being challenged to create land use plans that will provide a controlled and healthy environment for present and future generations. As a result of the growing concern for the quality of the environment, land use planning is becoming one of the major areas of interest to ensure that the necessary environmental safeguards, including those controlling undue noise impacts, are incorporated into land use policies and programmes at all levels of government and in the private sector. Careful planning is necessary to account for the conditions as they exist today and for the many years in the future and to account for the continued growth and changes in our living and physical environment.

The basic philosophy of traffic noise control in land use planning is to avoid future noise problems and complaints by either placing new residential (or other noise sensitive) areas away from existing noise sources or new noise sources away from existing residential areas.

Transportation noise sources, particularly vehicular traffic, are major sources of environmental noise pollution which may have an impact on the quality of life in populated areas. The effect of traffic noise on the urban environment is becoming an increasingly important consideration since noise is capable of interfering with human efficiency, personal comfort and the enjoyment of property.

Traffic noise seems to be the dominant transportation noise problem with railways a close second. Not only does the network of highways and railway tracks spread across Canada but the implication of noise from these sources on new development is worsened because these developments are more likely to occur close to the transportation corridors themselves due to the pressure for new development in developed urban areas.[1]

Both road and rail noise sources are restricted to ground level which makes control of their noise easier than that from aircraft or predominantly air-borne sources. For aircraft noise very little can be done for the outdoor environment apart from placing adequate distances between noise sensitive land use and the aircraft flight path.

NOISE AND THE PLANNING PROCESS:

It may well be thought possible under this heading to discuss what would be the ideal planning process as far as noise is concerned. The difficulties in attempting this are several, first the planning process cannot be wholly oriented towards a single facet such as noise. The planning process must necessarily cover many and often contradictory concerns such as air pollution, water pollution, sewage services, housing demand, marketability, economics and politics. No mater what the acoustical expert feels is best, the final decisions rest with the planning experts and decision makers who must of necessity take a broader view. Another important reason is the fact that a planning process does not appear over night, rather it is a gradual process of refinement and hopefully, improvement. The acoustician must take his place alongside others in this refining process, although he may have to work a little harder in order to catch up with the other long established land use planning considerations. He must ensure that his concerns can at least be presented and considered within the evolving planning process.

As land use planning in Canada is recognized as basically a local matter and as such is handled by the Provincial level of government (with delegation to the Municipal level in some cases), it follows that there will be some ten Provincial planning processes all in various stages of refinement and perhaps moving in different directions. In this paper, the provincial planning process in Ontario will be examined since noise considerations have been part of the planning process for several years.

LEGISLATIVE POWER:

As a first step, one must study existing means of exercising power or some form of control through Acts, regulations, government policies, codes, guidelines, etc. The inventory of such instruments to accomplish the final objective should be classified according to their application whether source oriented, or receiver oriented.

In Ontario, The Planning Act, administered by the Ministry of Housing, provides for the preparation, adoption, approval and legal effect of two statutory plans, the Official Plan and the Redevelopment Plan. The Act establishes a system of subdivision control and it delegates to local and regional municipalities power to enact zoning bylaws and to implement the provisions of the statutory plan. It also describes procedures for obtaining central government approval by the Minister of Housing or the Province's administrative agency, the Ontario Municipal Board, for local planning and land use control decisions. Although The Planning Act implies Ministry of Housing responsibility for the development of residential developments only; it is, in fact, responsible for the overall and general planning of all land uses including industrial, commercial, agricultural and rural land uses. Therefore, it may be concluded that The Planning Act is both source and receiver oriented legislation when dealing with environmental issues including noise pollution, especially at the earlier stages of the planning process when large tracts of land are designated for various uses.

It should be noted that the Act provides planners with broad power to control the development of incompatible land uses and that it does not contain any specific criteria for new noise sensitive developments. In fact, most of the specific criteria developed for evaluation of noise in new land use planning are contained within local policies developed by municipalities using the broad powers and provisions of The Planning Act. Good examples of such policies include the extensive noise policies dealing with surface transportation and aircraft noise in Official Plans recently approved in Ontario.

The Environmental Protection Act and The Environmental Assessment Act administered by the Ministry of the Environment deal with noise and vibrations as contaminants of the natural environment and both Acts provide for the protection and conservation of the natural environment. The Environmental Protection Act exercises control over the emission of noise from noise sources by prohibition, control orders, stop orders, work orders, approvals. Thus the problem of noise is tackled at the source rather than the receiver. For planning purposes, the provisions for approval of new sources of noise pursuant to The Environmental Protection Act are worthwhile noting as they affect the use of a particular property or tract of land. A use which may render adjacent properties incompatible.

The Environmental Assessment Act, another Act passed for the betterment of the people of Ontario, provides for the protection and conservation of the environment and wise land management. The Act applies to enterprises, activities, proposals, plans or programs that may affect the natural environment. In particular, the development of new surface transportation corridors or systems, or expansion of existing facilities would normally be subject to the provisions of The Environmental Assessment Act. Already several proposals for new highway projects and transit systems in Ontario have been the subject of examination with respect to their noise potential.

Concerning other noise policies in Ontario, the Ontario Ministry of Housing in cooperation with the Ontario Ministry of the Environment and the Ontario Ministry of Transportation and Communications have proposed a new provincial policy on new residential development adjacent to freeways. The new noise control policy deals with the approval of new residential developments adjacent to freeways, as well as the development of new freeways in Ontario. It outlines a basic framework for adoption and application of traffic noise policies and noise criteria when dealing with a specific situation.[2]

Earlier in March 1978, the Ontario Ministry of Housing in cooperation with the Ontario Ministry of the Environment prepared a land use policy for lands near airports based on the noise exposure forecast (NEF) system. This policy contains a land use compatibility table outlining acceptable land uses within given noise exposure forecast (NEF) values and the required acoustical insulation, if needed.[3]

Furthermore, the Ministry of the Environment has prepared numerous guidelines on planning with respect to noise. The interim guidelines were used during 1975 and 1976, and were later revised in July 1977 as part of a land use planning procedures manual with respect to noise. The manual is believed to be the first comprehensive document in Canada to deal with specialized and specific land use planning problems. The guidelines contained in the manual are basically receiver oriented in nature.[4]

In 1975, the Ministry of the Environment also published a Model Municipal Noise Control By-Law for adoption by local municipalities in Ontario under the enabling legislation, The Environmental Protection Act. The Model Municipal Noise Control By-Law, Final Report, August 1978, contains several guidelines for the benefit of those concerned with land use planning. Here the guidelines are aimed at both receiver and noise oriented land use planning problems and enforcement.[5]

THE PLANNING PROCESS AT THE VARIOUS GOVERNMENT LEVELS

This discussion outlines the role of the various levels of government as they may affect land use planning in Ontario. The federal government, although it does not have direct control as does the Provincial Government, can influence land use planning by its legislation, policies and programs on such matters as transportation, resource development, funding and land acquisition. The location of airports as well as the funding of new housing adjacent to airports are examples of how the federal government can influence land use planning. Legislation recently tabled in Parliament will seek to give the federal government control over land uses near an airport unless this power is being exercised by the provincial government and municipalities concerned.

Two particular federal government policies and programs are worth noting. The C.M.H.C. funding of new housing developments adjacent to roadways and railway tracks and the funding of new housing developments around airports. Both programs are related to the Central Mortgage & Housing Corporation's obligation to secure its direct financing under the National Housing Act. It must be emphasized here that although the C.M.H.C. standards apply to new housing development under these programs, they do not greatly affect land use planning at the provincial and local levels.[6,7]

Concerning the planning process at the provincial and local levels, it is extremely important that one understands the various steps and processes involved as they provide the vehicle for implementation and enforcement of noise policies related to land use planning. The planning process in Ontario involves a sharing of responsibilities between the provincial government and the upper and lower tier municipalities.

The planning process in Ontario involves the preparation of Official Plans and amendments thereto, Secondary Plans, Neighbourhood Plans, zoning by-laws, and subdivision plans. Ultimately, building plans are then submitted to the building departments of local municipalities for issuance of a building permit.

Official Plans are prepared by Regional and Local Municipalities outlining the program and policy for the planning area under consideration. The Draft Plan is then submitted to the Minister of Housing for approval. Prior to granting this approval, the Ministry of Housing requests the comments of the Noise Pollution Control Section; in addition to those of several other agencies on the circulation list, which may be incorporated into their conditions for approval. These plans are conceptual rather than detailed. When the Official Plan is eventually approved by the Minister of Housing it is binding in that all future zoning by-laws, applications for Draft Plan of Subdivision, municipal undertakings and private sector developments must conform to the Official Plan.

Considerable time and effort goes into the preparation of an Official Plan before it reaches the stage where it can be submitted to the Minister of Housing for approval. The Noise Pollution Control Section is often called upon at this stage in the formulation of the Official Plan and the form of assistance provided is varied but can be in terms of advising on general policy, acceptable sound level limits, sound level prediction techniques, feasible noise control measures, etc. Clearly this circulation procedure allows noise concerns to be voiced at an early stage in the planning process along with other concerns of importance. It is at this stage that the effects of existing and planned major transportation corridors on specific land uses are considered and integrated into the land use plan.

Secondary Plans, in general, contain the detailed implementation of the policies contained in the Official Plan. They describe the official policies concerning the physical, social, and economic development and redevelopment of specific areas within the planning areas of a municipality. Usually, Secondary Plans are prepared prior to consideration of development applications which makes them suitable for incorporation of specific and integrated noise control policies within the various parcels of land contained within such Secondary Plan. In fact, the most appropriate place in the planning process to consider noise control for "linear" sources of noise such as transportation corridors is during the formulation of Secondary Plans or Neighbourhood Plans.

Furthermore, the continuing cost of erecting noise barriers along stretches of freeways passing through existing residential areas has resulted in a new policy defining the provincial noise level objective for land uses near freeways.

Draft Plans of Subdivision are submitted by the applicants to the Ministry of Housing or the Regional Municipality for approval. Prior submission is not mandatory, however, as a matter of prudence most prospective subdividers consult with the local or area municipality before formally submitted their applications. The Draft Plan is then circulated to those Ministries and agencies whose advice is required in order to evaluate the Draft Plan. As a result of the review by the approving agency, the Draft Plan of Subdivision may be approved as submitted, approved with conditions, turned down completely or with advice as to how it could be made acceptable. The review of a Draft Plan of Subdivision includes consideration of health, safety, convenience, and welfare of the future inhabitants. In the case of potential noise problems, copies of the Plan are forwarded to the Noise Pollution Control Section who appraise the situation using noise prediction techniques wherever possible.

If necessary, it is also recommended that the developer maintain close contact with the Noise Pollution Control Section in order to discuss and agree upon the noise control measures required to reduce noise levels on the site to acceptable levels. In the case of an adverse comment involving noise, it is very often made a condition of draft approval that the developer give an undertaking to incorporate acceptable noise control measures in the Subdivision Agreement and Plans pertaining to the site. The terms of the Subdivision Agreement are binding on the developer.

Concerning zoning by-laws, implementation of the Official Plan requires that the municipality applies to the Ontario Municipal Board for approval of the zoning by-law which legally designates the land usage. The Ministry of Housing comments to the Ontario Municpal Board on the conformity of these plans with the Official Plan or an amendment thereto, after consultation, if necessary, with other interested agencies. Occasionally the Noise Pollution Control Section is called upon to advise on matters related to noise, or sometimes, appear as expert witnesses before the Ontario Municipal Board.

It can be seen that under the Ontario system, although no specific legal requirements existed in the past to persuade developers to institute noise control measures per se, ways have been found to formalize the noise input under the broad provisions and powers of The Planning Act and other legal instruments such as the Subdivider's Agreement. This formalization has resulted from continuous input and refinement. Such refinement would, no doubt, also occur within the planning processes of other provinces if noise was accepted as being a matter of public concern.

SOUND LEVEL OBJECTIVES IN HOUSING:

Before new residential developments can be designed to avoid problems caused by high environmental noise levels, sound level objectives and limits must be set to allow for an engineered solution in the form of noise control measures. Perhaps this is the most difficult part of the land use planning procedure with all the attendant implications. These limits are basically set as a compromise between two opposing influences; minimization of noise annoyance and minimization of the economic cost of noise control measures. The procedure for setting such sound level limits is relatively easy to define: choose the best noise rating method and then use that noise rating method to limit the community noise under consideration.

At this stage, however, one realises what a difficult task the setting of sound level limits can be. Numerous noise rating methods exist and papers are regularly published containing contradictory claims of the effectiveness of one rating method over another. Even after choosing one particular rating system, a limit must still be assigned above which the noise level may be deemed to be unsatisfactory. The fact that other pressures, namely economic and political, may confuse a decision made on simple health and welfare grounds does little to ease the task facing the acoustician. Perhaps recent attempts to define a single unified system for rating community noise may have greatly confused the issue.[8]

After carefully considering various sound level descriptors as well as experimenting with them in land use planning, in complaint investigations and in the approval of new noise sources; the Noise Pollution Control Section in 1975 recommended the use of several sound level descriptors including Leq, L50, L90, NEF, dBAI, and others depending on the application. For land use planning and surface transportation noise, the L_{eq} (for specific time periods) and the L_{50} are the main noise descriptors used.

In setting acceptable sound level objectives for new land use developments, the Ministry adopted interim criteria in 1974 based on the results of a study prepared for the United States Department of Housing and Urban Development (HUD). That report gathered together a large number of multinational references on community noise measurements and sociological surveys on reaction to noise. Out of this considerable literature survey came a set of guidelines for urban noise assessment in the form of a set of cumulative distribution curves delineating "clearly acceptable" "normally acceptable", "normally unacceptable" and "clearly unacceptable" areas of noise exposure as shown in Figure 1. This set of cumulative distribution curves were intended to replace HUD's interim standards set out in policy circular HUD 1390-2 which were not expressed in a standard statistical format and could not be directly compared with other international standards (many of which were framed in terms of either the statistical distribution or median L_{50} levels). Further experimentation with the ranges suggested by HUD in the evaluation of new land uses in Ontario, clearly indicated the impracticality of using such wide and flexible ranges in assessing new land uses.

Figure 2 represents a single coherent set of sound level limits for delineating between "acceptable" and "non-acceptable" sound levels. These were successfully used in designing new residential subdivisions during 1974 and 1975. The sound level limits listed in Figure 2 were later simplified by picking off certain, often used, statistical descriptor levels from the curve such as L_1, L_{10}, L_{50} and L_{90} in addition to the L_{eq}. The process of refinement continued during 1975 and this led to further simplification and the adoption of the sound level limits currently in use by the Ministry of the Environment as guidelines for evaluation of new residential and noise sensitive developments.

TRANSPORTATION NOISE:

Although the Noise Pollution Control Section is primarily responsible for enforcement of the legislation and planning, a significant portion of our technical resources is directed to cooperating with federal agencies such as Transport Canada and the National Research Council and standards organizations such as the Canadian Standards Association and in carrying out limited research in keeping with our role and objectives.

For example, this Ministry was instrumental in obtaining Transport Canada agreement to amend a proposed exterior truck maximum noise limit from 85 dBA to 83 dBA in 1977. The higher limit was originally published in the Canada Gazette, Part I, on July 10, 1976.

We have also cooperated with Transport Canada in subcommittees of the Canadian Standards Association to develop National Standards for the exterior noise of trucks, motor cycles, boats and rail vehicles. Likewise we cooperated in extensive field testing of heavy, governed diesel trucks to correlate the widely used passby SAE J1096 and SAE J366 procedures with the stationary test procedure CSA Standard Z107.22. The very high degree of correlation has led to the adoption of the CSA Standard Z107.22 in the Ontario Model Municipal Noise Control By-Law.

Other areas of interest related to transportation noise have led to Ministry funding of projects by various Ontario Universities. These are referred to as Experience Projects and are designed for maximum student involvement. Three Experience '79 projects are presently in progress. A study at the University of Windsor, for example, is looking at vehicle noise, particularly motor cycle noise, and the noise measurements are made using the Elmot sound level system, giving precise engine speed information through connection to the ignition system.

Funding has also been provided so that the National Research Council can employ students to look into thin barrier attenuation and thick barrier (barrier block) sound attenuation. At the same time, an internal project is comparing the two traffic noise prediction models most used by the Noise Pollution Control Section with actual traffic noise measurement at varying distances from the edge of highway. The objective is to refine and improve our capacity to predict transportation noise levels under varying conditions. Another facet of this work is the study of railway noise and marshalling yard noise. The data accumulated has enabled this Ministry to offer substantial assistance to agencies such as the EPA in Washington D.C. in preparing regulations on rail noise.[9]

Cooperation with the Ontario Ministry of Housing has led to the formulation of two significant provincial policies concerned with the effect of transportation noise. The first policy refers to land use near airports and the second policy refers to land use adjacent to freeways.[10]

THE MINISTRY OF THE ENVIRONMENT'S EDUCATIONAL PROGRAM:

Over the last four years the Noise Pollution Control Section, in reviewing over two thousand projects has gained considerable experience in planning with respect to noise. The experience has revealed the need to:

1. Disseminate widely the criteria and prediction techniques adopted by the Ministry, as well as the design and planning expertise acquired.
2. Establish a uniform approach to assessment by those concerned with the formulation of industrial plans and housing design particularly in the earlier stages of planning and development.
3. Streamline the review process.
4. Develop improved procedures and technology.

ACOUSTICS TECHNOLOGY TRAINING COURSES:

It is towards meeting these needs and fulfilling the Ministry's objectives that the various manuals of Environment Ontario's training courses have been prepared. They are designed to assist those concerned with land use planning and the provision of an acceptable noise environment in new developments and near new industry. From the beginning, the training course was designed with the following objectives in mind:

1. Reach those concerned in the planning, design and review of industrial, land use and residential developments irrespective of technical background. The training program is aimed at a wide spectrum of interested groups including planners in private and municipal government sectors, architects, consultants, engineers, developers and Ministry of the Environment regional personnel.
2. Enable a planner to "red flag" proposals because of potential noise impacts. This initial "sorting" speeds up the review of initial proposals for development by recognizing those projects which are, or are not, subject to serious noise impact.
3. Make planners aware of the common pitfalls and instill in them useful rules-of-thumb in the hope that initial proposals they process are much more soundly formulated.
4. Demonstrate, illustrate and evaluate the various noise control measures available along with their most efficient use in time and space.
5. Provide practical training in workshops, field measurement and study of actual case histories.
6. Provide an explanation of the legislation.

As far as we are aware, the Ontario Acoustics training program is the most comprehensive offered in North America by any level of government. More than 1,000 trainee-weeks of instruction and training has been provided since 1975.[11]

The educational program of the Ministry also includes a well planned series of short seminiars held throughout six regions in the Province of Ontario. Seminars are organized in the major centres and are usually well attended by many interested groups who prefer to attend local two-day seminars instead of the one-week training course offered in Toronto. Information on the courses may be obtained by contacting the Training and Certification Section of the Ontario Ministry of the Environment in Toronto.

REFERENCES:

1. "Rail Yard Noise", Report on Joint C.P. Rail Ontario Ministry of the Environment Symposium on Railway Noise, Toronto, Canada, July 1977.
2. "Guidelines on Noise and New Residential Development Adjacent to Freeways", Ontario Ministry of Housing, Toronto, Canada, April 1979.
3. "Land Use Policy Near Airports", Ontario Ministry of Housing, Toronto, Canada, March 1978.
4. "Acoustics Technology in Land Use Planning, Volume I, Analysis of Noise Impact", J. Manuel et al, Ontario Ministry of the Environment, Toronto, Canada July 1977.
5. "Model Municipal Noise Control By-Law, Final Report," Ontario Ministry of the Environment, Toronto, Canada, August 1978.
6. "Road and Rail Noise: Effects on Housing", Central Mortgage and Housing Corporation, #NHA5156, Ottawa, Canada, December 1977.
7. "New Housing and Airport Noise" Central Mortgage and Housing Corporation; #NHA5059, Ottawa Canada, November 1976.
8. "The Health and Welfare Effects of Transportation and Industrial Noise In Ontario," Ontario Ministry of the Environment Report, J.R. Hemingway and P. Dickinson et al, Toronto, Canada, December 1979.
9. "Invited Comments on Rail Carrier Docket EPA No. ONAC 79-01", Ontario Ministry of the Environment, Toronto, Canada, June 1979.
10. "Traffic Noise Control in Land Use Planning," J. Manuel and H. Gidamy, Roads and Transportation Association of Canada, Regina, Canada, September 1979.
11. "Environmental Acoustics Technology," Volumes I through IV, J. Manuel et al, Ontario Ministry of the Environment, Toronto, Canada, June 1977.

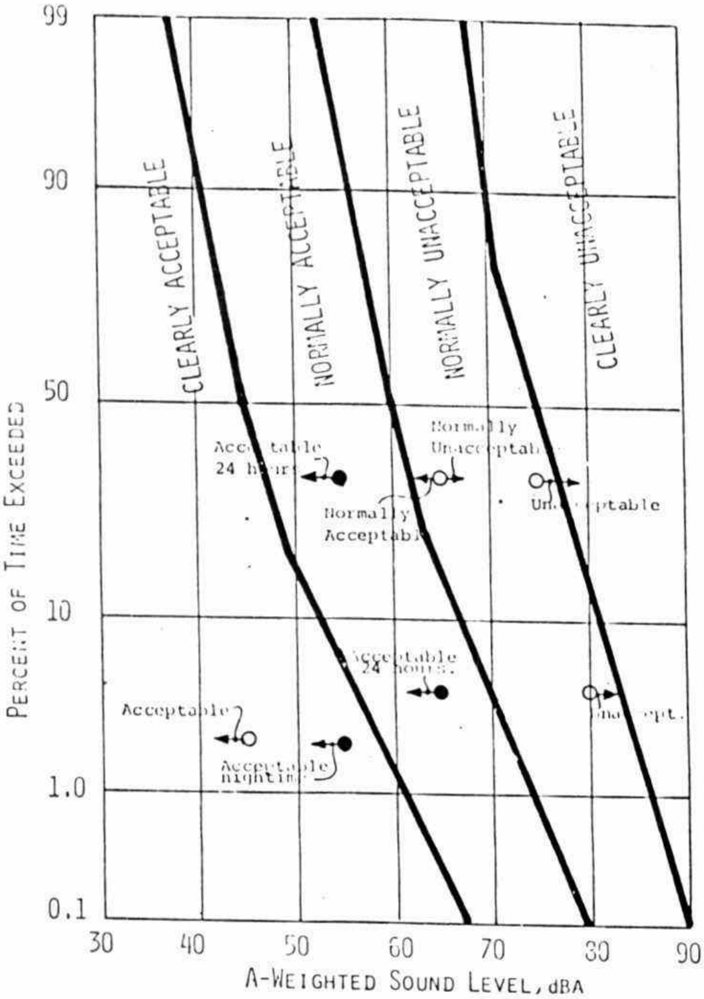


Figure 1: Cumulative A-Weighted level distributions that closely approximates the actual levels in HUD's interim policy for non-aircraft noise measured in residential areas.

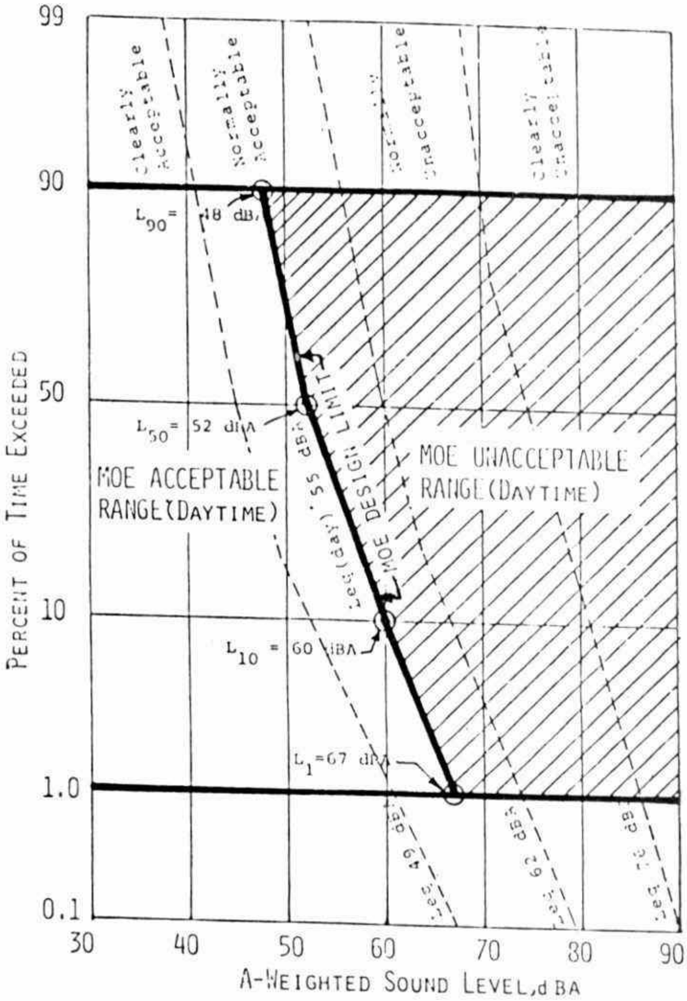


Figure 2: Original "Design cumulative A-Weighted sound level distribution" superimposed on the ranges suggested for HUD.

TRENDS IN ENVIRONMENTAL NOISE LEGISLATION

AND

INDUSTRIAL-RESIDENTIAL COMPATIBILITY

Presented to the Pollution Energy & Process Engineering Conference
Toronto, June 20th, 1979

by

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There is no question that government controls of environmental noise is increasing in complexity, and are evolving to encompass more sources and activities.

This is certainly the case in Ontario, other parts of Canada, the U.S., and many other highly developed and industrialized nations. In many respects, the regulation of noise is still in its infancy, with the legal mechanics, technological means of quantification, and development of criteria, still being actively researched. In many cases, there exists no legislation or regulations; but instead government "guidelines" that in practice turn out to be equivalent to regulations. This is particularly the case in the land-use approvals process in Ontario. More on this later.

In the available time, it would be impossible to cover all facets of the topic. I will concentrate on what is happening primarily in Ontario. Similar trends are occurring nationally and throughout North America. In some cases, we may be following other jurisdictions; in some cases, we may be ahead of other jurisdictions. Current environmental legislation and policy in Ontario is far reaching, and potentially affects all aspects of industry, commerce, and personal life.

It is probably a fair statement that, in all jurisdictions, (i.e. not specifically or only Ontario), the trend is to more stringent controls. However, the placement of the legal controls does not always automatically and necessarily imply enforcement.

What is noise? By definition, noise is unwanted sound. Some sounds are universally considered acceptable or desirable; some are universally agreed to be noise; some are controversial (e.g. rock music, the sound of a "straight-through pipe" on a sports car, etc.); some sounds would be desirable at one time, and noise at another time, or in a different context.

Noise, in many ways is unlike any other environmental pollutant.

Noise is energy, and leaves no residue as do environmental contaminants, such as chemicals. When the sound is turned off, there is no clean up problem.

Noise, strictly speaking, cannot be measured. All manner of physical characteristics of a sound can be measured, such as energy (sound level in decibels), frequency (pitch), build-up and decay, spectral energy distribution, etc. The final judgement is subjective, and no instrument can make the judgement. In industrial situations, within a plant, we may be dealing with sufficient sound energy that the sound level alone is an indicator of unacceptability, from the point of actual physical damage and hearing loss. However, outside, environmental sound levels, even in what are considered very noisy locations are not generally high enough to be of concern with respect to hearing loss. In many cases, the highly annoying or unacceptable sound levels impinging on residential development from an industrial facility fall in a range similar to that produced by acceptable sources of sound. For these situations, the question of acceptability criteria can be very difficult and sound level alone may be an inadequate descriptor to judge land use compatibility.

A sound or noise can be at or significantly below the prevailing ambient sound levels, and still be easily audible, if its other characteristics are different from the prevailing sounds. The amounts of energy we are dealing with to produce loud sounds are miniscule. This, compounded with the fact that our hearing mechanism behaves logarithmically, often makes the problem of control of environmental noise emissions very difficult. For example, a 200 Hp (150 kw) dozer may have a total acoustic output of $\frac{1}{100}$ to $\frac{1}{10}$ watt. This noise emission is one product of inefficiency. Thus, if the machine were perfectly efficient in all other respects, an efficiency of 99.99993% would still result in the same sound (noise) output.

Noise legislation as it affects industry and commerce may be divided into 3 general categories:--

1. ENVIRONMENTAL - this encompasses noise emissions into the environment in the context of impact on adjacent land uses and typically views the "contaminant" or "pollutant" from the point of view of the receptor.

2. PRODUCT - this relates to either noise emission limitations at the manufacturing level, or to the "in-use" situation of a product. This is a control at the source. In some cases, such as construction equipment or motor vehicles, the environmental controls may also be relevant or dominate. That is, the sound source may meet the product emission standards, but may infringe land use compatibility and environmental controls in the location or the way that it is used.

3. INDUSTRIAL HYGIENE - noise within the industrial work place is being increasingly regulated from the point of view of personnel health and safety. Typically, total sound energy exposure is limited in a manner analogous to that used for radiation. This category will not be dealt with here, except to say that elaborate provisions are in place in the U.S. and in Ontario, under Bill 70 (an Act respecting the Occupational Health and Occupational Safety of Workers) we are about to receive more extensive regulations than are in the current Industrial Safety Act.

Aside from the purely technical complexities of making appropriate measurements to quantify a given situation, one is often faced with the problem of split jurisdictions. Aircraft and railways are federally regulated. Noise is one aspect of the certification of commercial aircraft. The manufacture of motor vehicles is regulated by the federal Highway Safety Act. The control of their use is a provincial responsibility. Under the provincial Environmental Protection Act (EPA), environmental pollution is controlled. In Ontario, sound and vibration, as well as radiation, heat, odour, solid, liquid, gas, are within the definition of a "contaminant" in the EPA. At present, there are no regulations for noise and vibration under the EPA. Municipalities are also empowered to enact noise and vibration control by-laws under Section 95 of the EPA. These by-laws may set sound level limits, provide for licensing with respect to sound or vibration emissions, control hours of operation, etc.

Some municipalities, such as the City of Toronto, have in place noise by-laws that are actively enforced by a noise control group trained and occupied specifically in this regard. An increasing number of municipalities have, or are adopting by-laws such as the Model Municipal Noise Control By-law developed by the Ontario Ministry of Environment.

In some cases, legislation not dealing specifically with noise, in practice, results in environmental noise control becoming an implicit part of the process. For example, to operate a pit or quarry, a licence is needed. Section 6 of The Pits and Quarries Control Act, 1971, requires the Minister to refuse to issue a licence "where, in his opinion, the operation.....would be against the interest of the public taking into account,

a) the preservation of the character of the environment;
b) the availability of natural environment for the enjoyment of the public;
f) the nature and location of other land uses that could be affected.....".

Thus, in making application for a licence, and in operating the facility, potential noise and vibration impact must be dealt with.

Similar mechanics flow from the Environmental Protection Act, even though there are no noise or vibration regulations. Section 14 prohibits any person from causing or permitting the emission of a contaminant into the natural environment, that,

> "(a) causes or is likely to cause impairment of the quality of the natural environment for any use that can be made of it....".

Impairment of health and safety etc., is also prohibited, but as has been pointed out earlier, typical environmental sound levels encountered by the general public are well below the levels that can be shown to have any significant harmful physical effect.

Of significant import to industry and commerce in Ontario, is Section 8 of the EPA, which prohibits constructing, altering, or extending any plant, equipment, or thing that

> "may emit or discharge or from which may be emitted or discharged a contaminant into any part of the natural environment....."

without first obtaining a certificate of approval from the MOE. Since there are no regulations for noise, the process of obtaining a certificate for a potential noise source is not defined. One must simply make a good case on all environmental aspects, in order to obtain the approval.

In the absence of regulations for noise and vibration under the enacted legislation, there needs to be some "yardsticks" or criteria in order to attempt rational decisions in the approvals process for any type of development or project, and in the process of enforcing the "subjective" statutes. Therefore, a number of guidelines have been evolved to indicate the policy on which decisions may be based.

The guidelines cover noise control in land use planning; noise control in rural areas; information required for the assessment of planned stationary sources of sound; information required for assessment of planned new land uses with respect to sound and vibration impacts. The intent of the guidelines is to produce situations of compatibility of adjacent land uses. In addition, a number of technical "standards" or guidelines have been published by the MOE, covering: construction equipment of various types, residential air conditioners, domestic power tools, such as lawn mowers, motorized conveyances, small engine powered equipment, and blasting.These set sound level limits and are in a form suitable for inclusion in municipal noise by-laws. Thus, it appears that the province will retain the jurisdiction over approvals under the EPA, but delegate the enforcement for many in-use problems to the municipal level. Since much of the enforcement of sound level limits can be highly technical in terms of the required measurements, it is not clear that most municipalities would have the capability of such enforcement.

The effect of sound level limits for specific devices in by-laws, or published guidelines, whether enforceable in the field or not, has the effect of becoming a manufacturing specification limit for the product. For example, consider the case of a sanitary landfill operation using construction equipment. Even in a thinly populated rural area, there will likely be some residential use potentially impacted by noise. One of the requirements for the Certificate of Approval will be that amongst other noise abatement measures, the equipment used will meet the noise guidelines at least as of the date of manufacture. Therefore, it would be anticipated that as part of either the operating contract or equipment purchasing specifications, the noise emission limits would be included. The net result is to force suppliers to produce equipment meeting the guidelines, at least in the first instance.

In the case of the City of Toronto, noise emission standards were developed and incorporated in their purchasing specifications for air compressors and pavement brakes a number of years ago, in conjunction with preparation of their noise control by-law.

For the case of the introduction of a new potential noise (or vibration) source such as a new, altered, or expanded factory, there are no absolute criteria for noise or vibration emission applicable in all cases. For certain types of noise such as blasting or impact sound, the "guidelines" contain absolute limits. In situations where the sound environment is dominated by other man-made sources beyond control (e.g. close to a major highway), the criteria for the new sound source will be related to the existing environment and it must be shown that there will be no change or only an insignificant one. However, if the existing environment is dominated by a sound source under control of the applicant who wants to introduce an expansion or change, and if the noise he is already emitting is the subject of complaints from neighbours, he may find that in order to obtain a Certificate of Approval for the new portion, there will be great pressure to also introduce noise abatement in the existing process. Thus, in some cases, the complaint history or "neighbourhood relations" may have direct bearing on the technical requirements for new industrial developments adjacent to residential land use. It seems clear then that a good neighbour policy on the part of industry finding itself in potentially incompatible land use situations, would in the long run be self-serving and beneficial.

Industry should also be very wary of the encroachment of potentially incompatible land uses effected by means of zoning or official plan changes. The EPA does not distinguish who was present first. An industry may have located "in the middle of nowhere", deliberately to avoid incompatibility with adjacent land use. However, the spreading urban sprawl may create great pressure to rezone and develop housing next door. The industry may then be liable under the EPA, municipal by-law, or other guideline, simply because of proximity. Some of the sound or vibration limits mentioned above are formulated to apply at the nearest residence. Thus, they are not absolute limits, and in the absence of a close neighbour, a sound or vibration source may be in complete compliance.

From the opposite end of the spectrum, new residential development must meet relatively stringent noise criteria in the absolute sense. Approval for rezoning for residential use, or for subdivision of land in Ontario, is dependent on properly accounting for environmental noise sources, whether they be road traffic, airports, railways, or adjacent industries. Proper protection to meet the specified criteria must be provided to obtain approval under the Planning Act. In addition, the national agency, Central Mortgate and Housing Corporation, as of 1978 has added strict standards limiting environmental noise exposures to their specified criteria in order to obtain their funding.

In summary, it may be concluded that all sectors of industry and commerce must be properly cognizant of the potential noise and vibration impact to the environment that their operations or products may produce. It is obvious that an enlightened public is increasingly reluctant to accept environmental contaminants and has been effectively exerting great political pressure in this regard. In the long run, proper treatment of potentially adverse noise and vibration impact, commencing during preliminary design and concept evolution, will typically return dividends in speedier approvals, fewer complaints, and more acceptable products.

APPENDIX I

THE FOLLOWING GUIDELINES ARE EXTRACTED FROM THE MODEL MUNICIPAL NOISE CONTROL BY-LAW, 1978.

MODEL
MUNICIPAL
NOISE CONTROL
BY-LAW

Final Report

August, 1978

Information regarding contents
and implementation of this
document may be obtained from:

Supervisor
Noise Pollution Control Section
Environment Ontario
135 St. Clair Ave. West
Toronto, Canada
M4V 1P5

This document may be
obtained from:

Ontario Government Bookstore
880 Bay Street
Toronto, Canada
M7A 1N8

All technical publications related to the Model Municipal Noise Control By-Law issued prior to the date of this publication are no longer valid

KEY WORDS:

ACOUSTICS, AIRCRAFT, BIRD SCARERS, BLASTING, BY-LAW, DECIBEL, ENVIRONMENT, GUNSHOTS, IMPULSE, LAND-USE, LEGISLATION, NOISE, PEST CONTROL, PITCH, PLANNING, REGULATION, SOUND, TRAFFIC, TRAINS, TONE, STANDARD, VIBRATION.

Publication NPC-131

Guidelines for Noise Control in Land-Use Planning

1. Scope

This Publication refers to the noise environment on the site of proposed residential or other sound-sensitive development in an urban area. Specified sound-level limits should apply to a new development as well as alteration to, or conversion of, any existing development or construction.

2. Definitions

(1) Technical Definitions

The technical terms used in this Publication are defined in Publication NPC-101 - Technical Definitions.

(2) Definitions Specific to this Publication

(a) Outdoor Recreational Areas

"Outdoor recreational areas" refers to those outdoor amenity areas where the enjoyment of the outdoor environment is important. These amenity areas include, but are not limited to, the following:

- (i) yards including front yards, backyards, gardens, terraces or patios of dwellings;
- (ii) common outdoor areas allocated for recreational purposes such as areas outside apartment buildings, condominiums, group homes, hospitals and schools;
- (iii) parks and open spaces allocated for recreational purposes within a plan of subdivision.

(b) Control Measures

"Control measures" refers to actions which can be taken to achieve noise compatibility for the specific land use or activity. Control measures may include, but are not limited to, the following:

- (i) Site Planning - orientation of buildings and outdoor recreational areas with respect to noise sources, spatial separation such as insertion of sound-insensitive land uses between source and receiver and appropriate setbacks;
- (ii) Acoustical Barriers - berms, walls, favourable topographical features, other intervening structures;

(iii) Architectural Design - room and corridor arrangement, blank walls, placement of windows, balconies and courtyards, building height;

(iv) Construction - acoustical treatment of walls, ceilings, windows and doors, selection of acoustical materials and other control devices.

3. Indoor Sound Level Limits

(1) Table 131-1 as adjusted in accordance with subsection (2), if necessary, gives the equivalent sound level (L_{eq}) limits and the applicable time periods for the indicated types of indoor space. These are the minimum requirements of these Guidelines and apply in all cases.

(2) When the predominant sound has pronounced tonal quality such as a whine, screech, buzz, or hum or contains pronounced narrow bands of energy, then 5 dB should be deducted from the sound level limits indicated in Table 131-1.

4. Outdoor Sound Level Limits

(1) Table 131-2 gives the sound level limits for two descriptors,
the 50th percentile sound level (L_{50}) and
the equivalent sound level (L_{eq})
for outdoor recreational areas, where the descriptors are referenced to the entire 16 hour period from 07 00 to 23 00.
The 50th percentile sound level need only be considered for development where the predominant sound is industry or a highway producing near constant sound levels throughout the 16 hour period. Compliance with these sound level limits should generally ensure compliance with the appropriate requirements of Table 131-1 for the same time period for any normal building construction nearby.

(2) Table 131-3 gives the sound level limits for two descriptors,
the 50th percentile sound level (L_{50}) and
the equivalent sound level (L_{eq}),
for outdoor areas, in the vicinity of buildings or proposed buildings containing sleeping quarters, where the descriptors are referenced to the entire 8 hour period from 23 00 to 07 00
The 50th percentile sound level need only be considered for development where the predominant sound is industry or a highway producing near constant sound levels throughout the 8 hour period. Compliance with these sound level limits should generally ensure compliance with the appropriate requirements of Table 131-1 for the same time period for any normal building construction nearby.

Table 131-1
Indoor Sound Level Limits

Type of Space	Equivalent Sound Level (L_{eq}), dBA
Bedrooms, sleeping quarters, hospitals, etc. (Time period 23 00 - 07 00)	40
Living rooms, hotels, motels, etc. (Time period 07 00 - 23 00)	45
Individual or semi-private offices, small conference rooms, reading rooms, classrooms, etc. (Time period 07 00 - 23 00)	45
General offices, reception areas, retail shops and stores, etc. (Time period 07 00 - 23 00)	50

Table 131-2
Sound Level Limits for Outdoor Recreational Areas (07 00 - 23 00)

Sound Descriptor for the Entire Period	Sound Level Limit, dBA
L_{50}	52
L_{eq}	55

Table 131-3
Sound Level Limits for Outdoor Areas (23 00 - 07 00)

Sound Descriptor for the Entire Period	Sound Level Limit, dBA
L_{50}	47
L_{eq}	50

(3) Where the requirements of Table 131-3 cannot be met, special architectural design and construction features will have to be incorporated into the building to ensure compliance with the appropriate requirements of Table 131-1.

5. Planning the Project

(1) Responsibility of Developer

The developer or proponent of a new project, or project to convert an existing use, for a residential or sound-sensitive development in an urban area, should be responsible for investigating both the outdoor and potential indoor acoustical environments, and to determine the feasibility and the constraints applicable before any project action is taken or construction commitment made.

(2) Establishing the Sound Levels On-Site

The sound levels anticipated on the site should be established by the use of prediction techniques acceptable to the Minister, based when necessary on actual measurements. In all cases, consideration should be given to anticipated future increases in sound levels for at least ten years.

(3) Control Measures

When anticipated sound levels on the site of the land-use development under consideration exceed the recommended sound level limits, the land developer should institute appropriate control measures or revision to plans.

(4) Ventilation

Air conditioning or forced air ventilation systems should be provided when special architectural design or construction features used as control measures restrict indoor ventilation.

Publication NPC-132

Guidelines for Noise Control in Rural Areas

1. Scope

This Publication suggests sound level limits for stationary sources in rural areas where the acoustical environment is normally dominated by natural sounds and where road traffic, if any, is not frequent.

2. Definitions

(1) Technical Definitions

The technical terms used in this Publication are defined in Publication NPC-101 - Technical Definitions.

(2) Definitions Specific to this Publication

A "rural area" is an area with little or no road traffic such as the following:

(i) a small community with less than 1000 population;
(ii) farm land or land zoned rural or agricultural;
(iii) a rural recreational area such as a cottage or resort area; or
(iv) a wilderness area.

3. Measurement Standards and Procedures

(1) For the purposes of this Publication all measurements of equivalent sound level (L_{eq}) shall be made in accordance with Publication NPC-103 - Procedures;

(2) Measurement of the ninetieth percentile sound level (L_{90}) may be made during any one hour using instrumentation providing percentile sound levels or by a manual method using a General Purpose Sound Level Meter. In the manual method, three independent measurements shall be taken, each of which shall be the lowest slow response reading of the meter during a continuous period of at least 1 minute. The arithmetic mean of the three measurements shall be considered to be the ninetieth percentile sound level (L_{90}) of that hour.

4. Sound Level Limits

In a rural area, within 30 m of a dwelling or a camping area, in any hour, the equivalent sound level (L_{eq}) of a stationary source should not exceed the ninetieth percentile sound level (L_{90}) of the natural environment, by more than 10 dB.

5. Sound Level Limits

In a rural area, within 30 m of a dwelling or a camping area, in any hour, the ninetieth percentile sound level (L_{90}) of a stationary source should not exceed the ninetieth percentile sound level (L_{90}) of the natural environment, by more than 5 dB.

6. Sound Level Limits - Impulsive Sound

In a rural area, within 30 m of a dwelling or a camping area, in any hour, the Logarithmic Mean Impulse Sound Level (L_{LM}), as determined in accordance with Publication NPC-103 - Procedures section 3, for sound from a stationary source, should not exceed the higher of:

(i) the ninetieth percentile sound level (L_{90}) of natural sound plus 15 dB, or

(ii) 50 dBAI.

7. Sound Level Limits - Impulsive Sounds

In a rural area, within 30 m of a dwelling or a camping area, the impulse sound level from a stationary source which is not a planned blasting operation in a mine, quarry or construction should not exceed 100 dBAI.

8. Exclusion

No restrictions should apply to any stationary source resulting in an equivalent sound level (L_{eq}) or ninetieth percentile sound level (L_{90}) of 40 dBA or less within 30 m of a dwelling or a camping area.

9. Planning For Control of New Stationary Sources

Proponents of new or expanding projects having a potential noise impact in rural areas should obtain prior approval for the project in accordance with section 8 of The Environmental Protection Act. Publication NPC-133 - Guidelines on Information Required for the Assessment of Planned Stationary Sources of Sound provides information for making submissions.

Publication NPC-133

Guidelines on Information Required for the Assessment of Planned Stationary Sources of Sound

1. Scope

This Publication refers to information required for the assessment of planned stationary sources of sound, in compliance with section 8 of The Environmental Protection Act or for purposes of The Environmental Assessment Act. The guidelines apply to new sources of sound as well as expansion, alteration or conversion of existing sources.

2. Technical Definitions

The technical terms used in this Publication are defined in Publication NPC-101 - Technical Definitions.

3. Measurement Standards and Procedures

For the purpose of this Publication:

(1) all measurements shall be made in accordance with Publication NPC-103 - Procedures, and where appropriate, Publication NPC-132 - Guidelines for Noise Control in Rural Areas;

(2) traffic noise shall be determined in accordance with Publication NPC-106 - Sound Levels of Road Traffic.

4. Sound Level Limits

(1) Urban Areas

For a source in a developed area, where the existing sound environment is determined largely by the activities of man, the sound level due to the source should be shown to not exceed the existing sound level resulting from industrial activity and road traffic at a point of reception in a residential or recreational area. In particular:

(a) for impulsive sound from the source, with the exception of Quasi-Steady Impulsive Sound, the predicted Logarithmic Mean Impulse Sound Level (L_{LM}), of sound from the source at a point of reception, should not, in any hour of the day, exceed the larger of 50 dBAI or the combined one hour equivalent sound level (L_{eq}) of existing industry and existing road traffic, measured together as if they constituted a stationary source;

(b) for all other types of sound from the source including Quasi-Steady Impulsive Sounds, the predicted one hour equivalent sound level (L_{eq}) of sound from the source at a point of reception, should not, in any hour of the day, exceed the one hour equivalent sound level (L_{eq}) of existing industry and existing road traffic measured together as if they constituted a stationary source.

(2) Rural Areas

For a source in a rural area as defined in Publication NPC-132 - Guidelines for Noise Control in Rural Areas, where the existing sound environment is determined largely by natural sounds, and where road traffic, if any, is not frequent, the sound level due to the source should be shown not to exceed the existing background sound level at any point of reception within 30 m of a dwelling or a camping area. The following specific sound level limits apply:

- (a) for impulsive sound from the source, with the exception of Quasi-Steady Impulsive Sound, the predicted Logarithmic Mean Impulse Sound Level (L_{LM}) should not, in any hour of the day, exceed the higher of:
  - (i) the one hour ninetieth percentile sound level (L_{90}) of natural sound plus 15 dB, or
  - (ii) 50 dBAI.
- (b) for all other types of sound from the source, including Quasi-Steady Impulsive Sounds, the predicted one hour equivalent sound level (L_{eq}) of sound from the source should not, in any hour of the day, exceed the existing one hour ninetieth percentile sound level (L_{90}) of natural sounds by more than 10 dB. **The predicted one hour ninetieth** percentile sound level (L_{90}) of sound from the source should **also not, in any hour of the day, exceed the existing** one hour ninetieth percentile sound level (L_{90}) of natural sounds by more than 5 dB.

5. Required Information

The following represents the information which should be provided:

(1) Acoustical Characteristics of Sound Sources

- (a) relevant equipment specification, including model, manufacturer's name and all necessary supporting data or calculations;
- (b) sequence of operation of multiple, intermittent sources;
- (c) time varying characteristics of generated sound (steady or intermittent);
- (d) tonal characteristics;
- (e) impulsive characteristics;
- (f) directivity pattern of proposed source;
- (g) noise measurement techniques and equipment used for evaluation of source emission; and
- (h) octave or 1/3 octave sound power levels for the sources where available; or

(i) octave or 1/3 octave sound pressure levels generated by the sources including measurement conditions, procedure and location of measurement points; and

at relevant locations at the source property line and at critical points of reception the predicted,

(j) hourly equivalent sound level (L_{eq}) of the source;
(k) Logarithmic Mean Impulse Sound Level (L_{LM}) of the source;
(l) hourly ninetieth percentile sound level (L_{90}) of the source, if the source is in a rural area;
(m) sound level using other specialized descriptors.

(2) Acoustic Environment

(a) existing hourly ninetieth percentile sound level (L_{90}) at points of reception if the source is in a rural area;
(b) existing hourly equivalent sound level (L_{eq}) of road traffic;
(c) plot plan of the source indicating location and elevation of noise emission points, property boundaries, as well as location and elevation of the various intervening structures and objects;
(d) physical and topographical description of the grounds;
(e) area location plan indicating the nature of the neighbourhood around the source, including roads up to at least 500 m distance from the property line, location and heights of all buildings or other intervening structures within this distance. Where a large installation or industrial complex such as an oil refinery, steel mill, generating station or mine site, etc., is proposed, the area plan or map should show current as well as projected land use within a distance of approximately 1 kilometre from the property line;
(f) prevailing wind conditions.

(3) Abatement Features

Where sound sources are silenced, enclosed or shielded by barriers the location, dimensions, structural details and material used.

(4) Consideration for Air Blast (Concussion) and Vibration

Special consideration should be given in the submission to blasting causing concussion or ground vibration. The expected peak pressure level (dB linear peak) and peak particle velocity (cm/s) should be indicated at points of reception.

(5) Calculation Procedures

Details of methods, mathematical models used and assumptions made in deriving sound levels at relevant points of reception.

6. Assessment of Potential Noise Impact for Large Installations

(1) Large manufacturing and/or process plants or industrial complexes where a multitude of sources exist require elaborate analysis. The assessment of impact of such projects requires extensive sound level mapping in addition to information specified in Section 5. Since zoning changes can usually be expected to follow the establishment of such industrial complexes a complete on-going record of the relevant sound level contours of the area becomes an essential reference in the submission process and a complete program of sound level monitoring should be submitted by the proponent.

(2) The present level of road and rail traffic in the vicinity of the proposed installation should be stated and the increase in such traffic due to the plant's operation should be projected forward for a period of at least ten years.

7. Approval of Abatement Programs

Abatement measures planned to alleviate an existing noise problem are also subject to approval. The following information is required in a submission:

1. the specification of abatement equipment and materials such as, transmission loss, insertion loss and noise reduction;
2. if the devices are standard catalogue items, indicate the model and manufacturer's name;
3. all necessary supporting calculations;
4. if alternative measures for noise abatement are proposed, a full description of such alternatives, such as administrative steps, changes in operational procedure or structural alterations, should be provided.

8. Report Format

Information provided in a report should conform to the following general format. Analysis and evaluation by the Ministry will consist of checking the validity of the information based on the best available technology. Observance of the required format may expedite approval by the Ministry.

(1) Planning Objectives

The scope of the information provided should be predicated on, and include a statement of the planning objectives of the municipality and a statement of the planning objectives of the approving authority, if other than the municipality.

(2) Organization of the Report

The information should be presented in a concise, itemized form with appropriate headings. Sufficient copies of the information should be made available to the Ministry including plans, drawings and appendices.

(a) Body of the Report

The body of the report should contain the following information:

- (i) a brief description of the acoustic environment the site, listing all significant existing or proposed sound sources, their location and characteristics;
- (ii) sound levels at the site due to individual sources, preferably summarized in a Table;
- (iii) combined sound levels at the site due to individual sound sources, preferably tabulated for representative locations;
- (iv) a comparison between the projected sound levels on the site and the applicable standard;
- (v) the excess sound level above the applicable standard should be tabulated, if any;
- (vi) the location, nature and dimensions of noise attenuating structures or other noise control measures required to eliminate any excess over the applicable standard;
- (vii) if the report is in the form of a feasibility study leading to conditional approval of a project, it would suffice to indicate the location and the nature of outdoor and indoor sound sources and control measures.

(b) Appendices to the Report

The following information should be provided as appendices to the main body of the report:

1. projected data for all items of equipment,
2. projected data for train and highway traffic and growth due to airports and industry. Sources of data should be provided;
3. details of sound level measurements and equipment used; and
4. calculations used in predicting sound levels, barrier height and other acoustical aspects of the report.

9. Transmittal of Information

Reports prepared for submission to the approving authority or a municipality are normally circulated in the Ministry. Technical assistance in preparing a report may be obtained from the Noise Pollution Control Section of the Pollution Control Branch of the Ministry.

Publication NPC-134

Guidelines on Information Required for the Assessment of Planned New Land Uses With Respect to Sound and Vibration Impacts

1. Scope

This Publication refers to information required for the assessment of planned new land uses with respect to sound and vibration impacts, in compliance with provisions of The Planning Act, The Environmental Assessment Act and other relevant legislation. These guidelines apply to changes of Official Plans, rezoning, applications for subdivision approval and all new land uses adjacent to major transportation and energy corridors, industries and airports.

2. Technical Definitions

The technical terms used in this Publication are defined in Publication NPC-101 - Technical Definitions.

3. Measurement Standards and Procedures

For the purposes of this Publication:

(1) all measurements shall be made in accordance with Publication NPC-103 - Procedures, and where appropriate, the following Publications should be consulted,

  (i) Publication NPC-131 - Guidelines for Noise Control in Land-Use Planning,

  (ii) Publication NPC-132 - Guidelines for Noise Control in Rural Areas,

  (iii) Publication NPC-133 - Guidelines on Information Required for the Assessment of Planned Stationary Sources of Sound, and

  (iv) Publication NPC-106 - Sound Levels of Road Traffic.

(2) the site shall be designed so as to assure compliance with the sound level limits listed in either,

  (i) Publication NPC-131 - Guidelines for Noise Control in Land-Use Planning in all cases where the predominant sound is industry or a highway producing near constant sound levels throughout the observation period,

  or optionally,

  (ii) the applicable Central Mortgage and Housing Corporation publications on housing construction standards if the predominant sound is varying.

4. Required Information

The extent of sound monitoring or prediction of sound levels should be discussed with the Ministry at an early stage of planning. The following represents the information which should then be provided for relevant points of reception for the project under study:

1. Acoustical Characteristics of Existing and Potential Sound Sources External to the Planned Land Use
    - (a) where sound from a source is steady, the sound level in A-weighted decibels (dBA);
    - (b) where the sound level is varying, the equivalent sound level (L_{eq}), the 50th percentile sound level (L_{50}), and, if available, the applicable histogram and the cumulative distribution of sound for the period of observation;
    - (c) such other specialized sound descriptors and sound levels, as may be necessary to describe existing or predicted conditions; and
    - (d) description of the sound source with particular reference to tonal and impulsive characteristics and directivity pattern.
    - (e) where sound sources are enclosed or shielded by barriers, the locations, dimensions, and structural details should be provided;
    - (f) special consideration should be given to planned blasting operations. The expected peak pressure level (dB linear peak) and peak particle velocity (cm/s) should be indicated at points of reception;
    - (g) prevailing wind conditions.
2. Acoustic Environment at Site
    - (a) site plan indicating property boundaries and location and elevation of the various structures and objects on the site;
    - (b) physical and topographical description of the area;
    - (c) area location plan indicating the nature of the neighbourhood around the site including roads up to at least 500 m distance from the site property line, location and heights of all buildings or other structures within this distance and the location and elevation of sources of sound.

(d) assessment of the impact of major projects requires extensive sound level mapping and, since zoning changes can usually be expected to follow, a complete on-going record of the relevant sound level contours of the area becomes an essential reference in the approval process A program of sound level monitoring should be submitted by the proponent;

(e) the present level of road and rail traffic in the vicinity should be stated and any expected increase in such traffic should be projected forward for a period of at least ten years;

(f) where noise control measures or abatement measures are required to reduce present or future sound problems, detailed information should be provided on the planned measures and the estimated effect.

3. Preparation of Impact Statement

The extent of sound monitoring or prediction of sound levels should be discussed with the Ministry at an early stage of planning. An impact statement must be prepared which adequately describes the present conditions and the predicted changes over, at least, a ten year period.

5. Report Format

Information provided in a report should conform to the following general format. Analysis and evaluation by the Ministry will consist of checking the validity of the information based on the best available technology. Observance of the required format may expedite approval by the Ministry.

(1) Planning Objectives

The scope of information provided should be predicated on, and include a statement of the planning objectives of the municipality and a statement of the planning objectives of the approving authority, if other than the municipality.

(2) Organization of the Report

The information should be presented in a concise, itemized form with appropriate headings. Sufficient copies of the information should be made available to the Ministry including plans, drawings and appendices.

(a) Body of the Report

The body of the report should contain the following information:

(i) a brief description of the acoustic environment at the site, listing all significant existing or proposed sound sources, their location and characteristics;

(ii) sound levels at the site due to individual sources, preferably summarized in a Table;

(iii) combined sound levels at the site due to individual sound sources, preferably tabulated for representative locations;

(iv) a comparison between the projected sound levels on the site and the applicable standard;

(v) the excess sound level above the applicable standard should be tabulated, if any;

(vi) the location, nature and dimensions of noise attenuating structures or other noise control measures required to eliminate any excess over the applicable standard;

(vii) where the report is intended to clear conditions of draft approval leading to registration of the plan of subdivision, all sound control measures should be sufficiently detailed to be entered into the Subdivision Agreement or the Engineering Agreement required by the municipality. The detailed indoor and outdoor sound control measures should be listed in a manner permitting ready checking off by an authorized building inspector during construction; and

(viii) where the report is in the form of a feasibility study leading to draft approval of a subdivision, it would suffice to indicate the location and the nature of outdoor and indoor sound control measures.

(b) Appendices to the Report

The following information should be provided as appendices to the main body of the report:

1. projected data for train and highway traffic and growth due to airports and industry. Sources of data should be provided;
2. details of sound level measurements and equipment used; and
3. calculations used in predicting sound levels, barrier height and other acoustical aspects of the report.

6. Transmittal of Information

Reports prepared for submission to the approving authority or a municipality are normally circulated in the Ministry. Technical assistance in preparing a report may be obtained from the Noise Pollution Control Section of the Pollution Control Branch of the Ministry.

APPENDIX II

THE FOLLOWING NOISE GUIDELINES ARE BEING REPLACED WITH A NEW PROVINCIAL NOISE POLICY PRESENTLY BEING CONSIDERED BY THE MINISTRIES OF HOUSING, ENVIRONMENT AND TRANSPORTATION & COMMUNICATIONS.

THE NEW POLICY WILL LIKELY INCLUDE BOTH OUTDOOR AND INDOOR NOISE LEVEL OBJECTIVES. THE OUTDOOR LEVELS WILL BE SIMILAR TO THOSE APPEARING IN THE EXISTING GUIDELINES WHILE THE INDOOR OBJECTIVE LEVELS WILL BE SIMILAR TO THOSE APPEARING IN PUBLICATION NPC-131 OF THE MODEL MUNICIPAL NOISE CONTROL BY-LAW, 1978.

Ontario

Ministry of
Housing

Guidelines on noise and new residential development adjacent to freeways

Minister's statement on noise and new residential development adjacent to freeways

Mr. Speaker:

In February of 1977, the Ministers of Transportation and Communications and Housing announced that, "where feasible," noise barriers would be provided by the Ministry of Transportation and Communications for new construction work on major freeways through existing residential areas. It was also stated that developers of new residential units near freeways would have to include similar measures to reduce noise impact.

We are now able to introduce guidelines to control the noise in outdoor areas of new residential developments near freeways. I am pleased to announce a new policy which has been formulated in consultation with the Ministries of the Environment, and of Transportation and Communications.

Briefly, Mr. Speaker, this new policy sets an objective of 55 decibels as an outdoor noise level in residential developments adjacent to freeways. Where the outdoor noise level is likely to be excessive, the developer must demonstrate that measures will be taken to get as close as possible to this objective level of 55 decibels.

In those cases where the attenuated outdoor noise level exceeds 70 decibels, residential development will be prohibited, because this is the level where extensive community dissatisfaction occurs.

My ministry, in co-operation with the Ministries of the Environment and of Transportation and Communications, will be forwarding guidelines on outdoor noise levels for new residential development to all municipalities. This material also indicates some techniques which could be used to reduce the noise impact. Copies of these guidelines will also be provided to all members.

Noise control guidelines are also being prepared relative to the *indoor* sound environment, and these should be ready in the near future.

Guidelines on noise and new residential development adjacent to freeways

Introduction

A policy dealing with current problems of freeway noise in *existing residential areas* and with noise problems associated with freeway construction or reconstruction through *existing residential areas* was jointly announced by the ministers of Transportation and Communications, and of Housing in February 1977. It stated that, *"where feasible"*, noise barriers would be provided and that a developer, proposing to build residential units adjacent to a freeway, would be required to take appropriate measures to reduce noise impact.

It is unrealistic to suggest prohibiting all new residential development close to freeways since it is often technically, administratively and economically practicable to design new developments and/or incorporate measures in such a manner that noise is reduced to acceptable levels. Also, it is recognized that developers have varying degrees of flexibility to attenuate sound.

Consequently, it was considered desirable to establish sound level limits for noise control in *outdoor recreational areas* for new residential development adjacent to freeways. (Appropriate noise control guidelines are being prepared by the Ministry of Housing to ensure that the *indoor sound environment* of new residential development near freeways is also protected.)

Definition of 'freeway'

For the purposes of this policy, "freeway" is defined as an existing completed, partially developed or proposed provincial or municipal divided arterial highway that is accessible only from intersecting arterial streets at grade-separated interchanges.

Definition of 'outdoor recreational area'

For the purposes of this policy, "outdoor recreational area" is defined to mean an outdoor living area immediately adjacent to the housing unit designed to accommodate a variety of individual outdoor activities.

Sound level measurement

For the purposes of this policy, the noise level is the A-weighted 24-hour equivalent (L_{eq}) sound level based on either the Average Annual Daily Traffic (AADT) data or, where available, the Summer Average Daily Traffic (SADT) data, whichever is the higher. The equivalent (L_{eq}) sound level is a good indication of how people react to freeway noise.

Generally, the public reacts to noise when sound levels in outdoor recreational areas exceed 55 decibels (dBA). Public concerns, dissatisfaction, and complaints increase rapidly from approximately this level.

Policy on noise and new residential development adjacent to freeways

- The objective for predicted sound levels in outdoor recreational areas is 55 dBA or less.
- The province will not impose additional noise attenuation on the developer where the level is at or below the objective level.
- The developer shall be required to prove to the satisfaction of the approving authority, in accordance with provincial guidelines, that the noise level in outdoor recreational areas after applying attenuation measures is the lowest level technically, administratively and economically practicable. Any consideration of relief from achieving the objective level will be based on specific site characteristics, such as topography, existing development and the available sound attenuation options. Residential development will be prohibited where the *attenuated sound level* in outdoor recreational areas will exceed 70 dBA.
- The Ministry of Transportation and Communications shall plan to achieve an *attenuated sound level* as low as technically, administratively and economically practicable below 70 dBA where a freeway is proposed to be built or expanded through a developed residential area.
- Where the noise levels are expected to exceed 55 dBA in outdoor recreational areas after the implementation of sound attenuation measures, the approving agency for any new residential development shall require as a condition of approval that the developer inform prospective purchasers of residential lots which are so affected of the noise situation by posting a sign or by other appropriate means.
- Where residential development for which noise control measures will be required precedes the construction of a designated freeway, the approving agency *may require* as a condition of approval that:
  (a) sufficient lands be conveyed at no cost for erection of a noise barrier; and/or,
  (b) a pro-rated cost contribution be made prior to final approval for barrier construction, if barriers are considered necessary at the time of final approval.

Purpose of guidelines

The purpose of these guidelines is to ensure that sufficient data is made available by a developer to the approving authority demonstrating the achievement of the lowest technically, administratively and economically practicable noise levels for new residential development, in accordance with the provincial policy on Noise and New Residential Development Adjacent to Freeways. The analysis and evaluation by the approving authority will consist of checking the validity of the submission based on the best available acoustical information.

Noise control measures

In order to obtain relevant information for noise attenuation, a developer should make early contact with the Ministry of the Environment when the development is within one kilometre of the edge of a freeway right-of-way. The distance may vary with different conditions of traffic, topography and existing development.

Any consideration of relief from achieving the objective level of 55 dBA will be based on specific site characteristics, such as topography, existing development and the available noise control options. Control measures may include, but are not limited to, the following:

i) **Site Planning**—orientation of buildings and outdoor recreational areas with respect to noise sources, spatial separation such as insertion of sound-insensitive land uses between source and receiver and appropriate setbacks; and

ii) **Acoustical Barriers**—berms, walls, favourable topographical features, other intervening structures.

Guidelines

Land use planning principles

Planning principles should be adopted that minimize the chances of creating noise problem areas. Put simply, it means a proper place for every land use so that each use is compatible with the surroundings.

The overall goal should be to reduce the amount of residential land adversely affected by freeway noise. Residential areas should normally be located away from freeways. Wherever possible, commercial, light industrial, recreational and agricultural uses should buffer residential areas from noisy freeway traffic. If a residential area must be located near a freeway, suitably-designed medium and high density residential buildings are more adaptable to the noise environment than low density single-family units. Also, they perform the function of the noise barrier (barrier block) for the rest of a residential site.

Official plans and amendments

(a) If an official plan, relevant amendment, or secondary plan is under preparation, a municipality should consult with the Ministry of the Environment regarding appropriate noise control statements to be included in the plan.

(b) When an official plan or relevant amendment is submitted to the Region or the Ministry of Housing for approval, the provincial policy on Noise and New Residential Development Adjacent to Freeways will be included in the plan or amendment by modification if the municipality has not already done so.

Plans of subdivision

(a) Prior to making a subdivision application, a developer should obtain information on the necessary actions to be taken from the Region or the Ministry of Housing. At this stage, a developer may be instructed to consult the Ministry of the Environment and the Ministry of Transportation and Communications.

(b) When the plan of subdivision is submitted to the Region or the Ministry of Housing for approval, the Region or the Ministry of Housing will ensure that the subdivision conforms to the provincial policy by circulating the plan of subdivision to the Ministry of the Environment and the Ministry of Transportation and Communications for comments and technical advice on noise control measures.

(c) The Region or the Ministry of Housing, upon weighing this advice against other technical, administrative and economic considerations, may then give draft approval with appropriate conditions.

The implementation of the conditions will be achieved through a subdivision or development agreement.

Zoning bylaw amendments

(a) Since site planning is a major noise control measure, municipalities should use Section 35a of *the Planning Act* to implement appropriate conditions*. Publications on noise control measures are available from the Ministry of the Environment.

(b) Before passing a zoning bylaw amendment for a development affected by freeway noise, a municipality should refer the amendment to the Ministry of the Environment for comments.

(c) If the municipality passes such a bylaw without having regard to the provincial policy, the Region, the ministries of Housing, the Environment and, if a provincial freeway is involved, the Ministry of Transportation and Communications, will have to determine whether or not a potential noise problem exists and, if necessary, may object to the Ontario Municipal Board.

Special information required

The information required for review and evaluation of proposals for new residential development should include the following:

(a) **Location of freeways-**The plans should indicate the existing or planned future location of freeways within one kilometre.

(b) **Site plan-**The site plan should show the topography of the site, elevation and layout of the various existing buildings or proposed structures.

(c) **Establishing the noise levels on site-**The noise levels anticipated on the site should be established by the use of prediction techniques acceptable to the region and the Ministry of the Environment based, when necessary, on actual measurements. In all cases, consideration should be given to anticipated future increases in noise levels for at least ten years.

Current traffic information and traffic predictions for any particular provincial freeway may be obtained from the Ministry of Transportation and Communications. Developers may obtain further information on traffic noise prediction techniques from the most up-to-date government publications, from acoustical literature, and from the Noise Pollution Control Section of the Ministry of the Environment, Toronto.

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*Ministry of Housing. *Guidelines for Development Control (Site Plan Control)—The Planning Act: Section 35a.* February 1975.

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APPENDIX III

CMHC NOISE GUIDELINES

- ROAD AND RAIL NOISE: EFFECTS ON HOUSING

Road and Rail Noise:

Effects on Housing

Prepared in cooperation with the Division of Building Research of the National Research Council of Canada.

Central Mortgage
and Housing Corporation

Société centrale
d'hypothèques et de logement

Honourable André Ouellet
Minister of State
for Urban Affairs

Introduction

Public Concern

Noise pollution is recognized as contributing to a general deterioration of the environment and public interest is rapidly developing in urban traffic noise.

Social surveys from various parts of the world indicate that the noise from surface traffic gives rise to more neighbourhood dissatisfaction than that from aircraft. One reason is that surface traffic noise is not restricted to relatively specific areas such as around airports but pervades almost any built up area in modern society.

Canadian Action

All three levels of government have responsibilities in noise abatement. At the Federal level the responsibilities include aircraft noise and the setting of noise standards for all manufactured goods, and industrial noise.

Provinces deal with highway noise abatement and share responsibility for industrial noise abatement with the Federal Government. Various highway traffic acts concerning noise refer to such items as horns, faulty mufflers and squealing brakes.

In addition provincial governments authorize municipalities to create by-laws; most legislation has been passed at this level — in the form of anti-noise by-laws. This noise legislation however is extremely varied among communities.

Nuisance by-laws which prohibit "loud, unusual or disturbing" sounds in a neighbourhood are difficult to enforce due to their subjective nature. Where the by-laws establish quantitative limits in decibels for specific offensive noises, difficulties arise where traffic is concerned, in obtaining noise measurements which are defensible in court.

Existing legislation is directed at individuals and the noise they make and not at the total noise produced by a stream of traffic.

CMHC Involvement

To improve the design of new housing projects, the Corporation has, for a number of years, reviewed proposed subdivision plans prior to their acceptance for mortgage financing or insurance under the National Housing Act.

In 1956 Builders' Bulletin No. 79 was published as a guide for builders designing subdivisions and attention was drawn to the adverse effects of "Adjacent Sources of Nuisance to Residents". Trunk roads and railways were included in this category and a number of solutions were recommended. Subsequently these recommendations were refined and were published as requirements in the "Site Planning Handbook" in 1970. The requirements for housing were listed in terms of minimum distances from noise sources, site treatment relative to various classes of roads, and distances and screening for railways were recommended as well. In both cases, reference was made to a possible reduction in distances "where measures to improve soundproofing had been taken". No indication was made however of the reduction in noise that may be achieved by 1) the introduction of sound insulation or 2) the erection of noise barriers. These requirements are repeated in "Site Planning Criteria" to be published in 1977, replacing the "Site Planning Handbook". In the new publication the proviso is added that "where measures are taken to improve the sound insulation" the resulting noise levels may not exceed certain specified levels. These levels are detailed in this document.

Supplement to the Site Planning Criteria

This publication, issued as a supplement to "Site Planning Criteria", deals specifically with new residential development which may be adversely affected by noise from roads and railways.

Methods are suggested for determining the noise level at a building/site and where levels are too high, reducing them to acceptable limits within the various parts of the building where the noise occurs. In some instances the availability of NHA financing will depend upon the inclusion of noise reduction measures. Relevant criteria are therefore established in this document. It is hoped that developers and all levels of government will take these criteria into consideration when preparing comprehensive land use plans.

National Research Council

The Division of Building Research of the National Research Council has contributed substantially to this supplement which is based upon the best information available. Although it is hoped the requirements will be appropriate for several years, they will be subject to continuous review and updated on the advice of the National Research Council.

Part 1
Noise

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Noise Levels

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Section D — Classification of Areas Adjacent to Roads and Railways
Introduction

Section A — Noise

Introduction

Before attempting to discuss traffic noise which is primarily a social and community problem, it might be useful to consider briefly what noise is and what its effects are.

Sound is the sensation caused by fluctuations in air pressure detected by the human ear. When that sound is unwanted by the recipient it is described as noise.

Noise can affect people in a variety of ways, the most important of which may be damage to hearing, interference with communications, interference with concentration, disturbance of sleep and general annoyance. Any or all of these factors could lead to a reduction of efficiency and general well-being.

Individual reaction to the same sound intensity and source varies considerably from person to person. What may be annoying to one person may be acceptable to another.

One's environment has a distinct bearing on what may be considered excessive noise. Factory workers may require protection against hearing loss. Noise levels in offices must allow adequate communication or concentration. In the home, people are entitled to enjoy their privacy free from noises that interfere with their activities.

To allow for the great variations in the reactions of individuals to noise, any requirements designed to deal with the problems it causes have to be based on the average reaction.

It is not easy to define noise in a wholly satisfactory way, but for the purpose of this document an acceptable definition is "sound which is undesired by the recipient". This simple description emphasizes the fact that noise is subjective and its assessment is a matter of human values and environments.

Noise Levels

While everyone is conscious of noise, very few people have any idea of the level of noise and tend to describe it in terms of annoyance, ranging from acceptable to very annoying. Section B discusses the evaluation of traffic noises in general terms and presents some examples of the noise levels to which people are normally exposed.

Section B — Traffic Noise

Introduction

Noise from road traffic fluctuates in a more or less regular fashion throughout the day. The more distant a person is from the traffic the lower and steadier the noise level; the closer he is the higher the average level and the more obvious the noise peaks become. This is also true for rail traffic which generates higher peak levels of a more intermittent nature. In general, road traffic noise is anonymous coming as it does from a stream of vehicles; under the circumstances, it is difficult to attribute noise to a particular vehicle, whereas train noise can be attributed to a specific train.

The effects of traffic noise are greater in dwelling units than in some offices and factories where internal activities frequently generate more noise than enters from the outside. Hospitals and schools can be seriously affected by noise.

Whatever improvements take place in reducing vehicle noise will take a long time to become apparent and may even be offset by the ever increasing number of vehicles on the roads. Although traffic engineering recognizes noise problems it has different priorities and objectives and can only deal with noise in limited ways, by, for example the construction of berms on major highways. The architect and the planner however have the most effective means of improving the environment and in particular the residential environment: careful orientation of housing may easily reduce the apparent noise level by 50% or more.

It is important, therefore, that noise control be considered at the planning stages of any new building.

Evaluation of Traffic Noise

The noise problem can be considered under three broad headings: source, propagation and the receiver environment. In the case of surface traffic noise the source is traffic, made up of a varying number of vehicles of different types, and the roadway or railway track on which the traffic moves. The propagation of the noise is influenced by the level of the road or track above or below the surrounding grade, the distance and shielding between the road or track and the receiver, and the type and configuration of the ground between them.

The basic physical measure of noise used in this report is the A-weighted sound level, sometimes labelled "dB A". This is an overall measurement of all components of the sound, over the full range of frequencies with special weighting of the middle frequencies, to simulate the way the human ear responds to sounds of different frequencies. The A-weighted level has been found to correlate well with people's judgement of the loudness or annoyance of many kinds of noise, including road and rail traffic. A rough rule of thumb is that an increase of 10 dB in sound level doubles the apparent loudness.

It should be noted that aircraft noise is usually described in somewhat different terms. However, the procedures previously presented for specifying sound insulation of houses near airports* are essentially the same as those described here.

There are two basic types of identifiable intruding noises which increase the outdoor noise level above the background level — these are steady or semi-steady constant noises and intermittent single unrelated noises. The background noise level is that which remains after all identifiable traffic noises have been eliminated.

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*"New Housing and Airport Noise", NHA 5059, Central Mortgage and Housing Corporation.

Fig. 1 — **Common noise levels and typical reactions**

Sound Source	Noise Level	Apparent Loudness	Typical Reaction	CMHC Requirements		
	dB			Categories	dB	Maximum Acceptable Levels
	135		Painfully loud			
Military Jet	130	Sixty-four times as loud	Limit amplified speech			
Jet takeoff at 200′	120	Thirty-two times as loud				
	110	Sixteen times as loud	Maximum vocal effort	Unacceptable		
Jet takeoff at 2,000′	100	Eight times as loud				
Freight Train at 50′	95					
Heavy truck at 50′ Busy city street	90	Four times as loud	Very annoying Hearing damage (8 hours)			
	80	Twice as loud	Annoying			
					75	
Highway traffic at 50′	70	Base reference	Telephone use difficult	Unacceptable without adequate sound insulation		
	60	Half as loud	Intrusive			
Light car traffic at 50′					55	Outdoor Recreation
Noisy office	50	Quarter as loud	Speech interference	Normally acceptable	45	
					45	Kitchens Bathrooms
Public Library	40	Eighth as loud	Quiet		40	Living/ Dining
					35	Bedrooms
Soft whisper at 15′	30	Sixteenth as loud	Very quiet			
	10	Sixty-fourth as loud	Just audible	Acceptable		
Threshold of hearing	0					

NOTE: The minimum difference in noise level that is noticeable to the human listener is 3 dB. A 10 dB increase in level appears to double the loudness while a 10 dB decrease halves the apparent loudness.

Section C — Acceptable Levels of Traffic Noise

The acceptance of noise depends on the characteristics of noise and also on the activities of the listeners. The activities most affected by noise fall into two categories corresponding to two different criteria. For activities similar to speech communication (including listening to radio and television), the first requirement is that the noise level not interfere significantly with comfortable speech communication or with the perception of soft music. The other important category is sleeping: noise, especially at night, should not interfere with normal sleep patterns.

To deal with the fluctuating character of traffic noise it is convenient to describe it in terms of the equivalent level (L_{eq}). This is the level of a steady sound carrying the same energy, in a given time, as the fluctuating sound. For the purposes of this document the noise level is the A-weighted 24-hour equivalent (L_{eq}) sound level and will be defined simply as the noise level in decibels (dB). The value (L_{eq}) may be relatively constant during periods of high traffic flow, but in light traffic it will be sensitive to the passage of individual noisy vehicles. The 24-hour average value will mainly reflect the daytime level, but will also reflect the occasional nighttime peak.

The maximum equivalent level that will not impair sustained conversational speech is 40 dB. Noise above this level causes people to raise their voices and thus is not acceptable for a quiet indoor environment. In order to hear the quieter passages of music, a level of about 35 dB would be preferred. Communication in a slightly raised voice is acceptable in kitchens and bathrooms and usually in outdoor recreation areas.

Sleep arousal and interference with going to sleep depend on the level of noise and on the fluctuations in level or character that occur. A useful criterion is that the maximum levels not exceed the indoor background level by more than about 5 dB. Quiet interior levels range from 25 to 35 dB. Normally nighttime traffic is less dense than daytime traffic and the 24-hour average level provides a fair measure of maximum nighttime levels. The maximum value acceptable in bedrooms is 35 dB.

Outdoor noise levels as well as indoor levels should be considered because residential areas should include some space for outdoor recreation, such as patios, balconies and play areas. Experience indicates that somewhat higher noise levels are generally more acceptable outside than inside. An appropriate outdoor noise level is 55 dB, which would typically correspond to an indoor level of 40 dB. These levels would permit conversation most of the time at close range or in a slightly raised voice. Such background noise may serve the purpose of masking more specific sounds such as conversation on a neighbour's patio.

To meet these various criteria of acceptable noise levels the levels given in Table 1 have been adopted by CMHC.

Table 1

Maximum acceptable levels of road and rail traffic noise in dwelling and in outdoor recreation areas

	Noise Level
Bedrooms	35 dB
Living, dining, recreation rooms	40 dB
Kitchens, bathrooms, hallways, utility rooms	45 dB
Outdoor recreation area	55 dB

In an ordinary dwelling complying with "Residential Standards" the indoor noise level should be at least 20 dB below the outdoor level when windows are closed. If the outdoor noise level is no more than 55 dB, then all the proposed requirements could normally be met by construction complying with "Residential Standards" although it might still be prudent to locate bedrooms on the quieter side of the building.

In noisier locations some shelter is needed for outdoor recreational space so it meets the 55 dB requirements. The shelter might take the form of a barrier wall, solid fence or berm between the road and the recreational space. In some layouts the building itself, row housing for example, may form an adequate barrier to protect outdoor space on the sheltered side. Generally, however, a reduction of 20 dB is the maximum that can be expected from a barrier. It follows that outdoor space that is quiet enough cannot be achieved at sites where the noise level is greater than 75 dB.

NOTE: The noise from road traffic at a site is directly related to any possible combination of the following conditions: average vehicle speed, density of traffic flow, the proportion of trucks to cars, the number of lanes and the distance to the site.

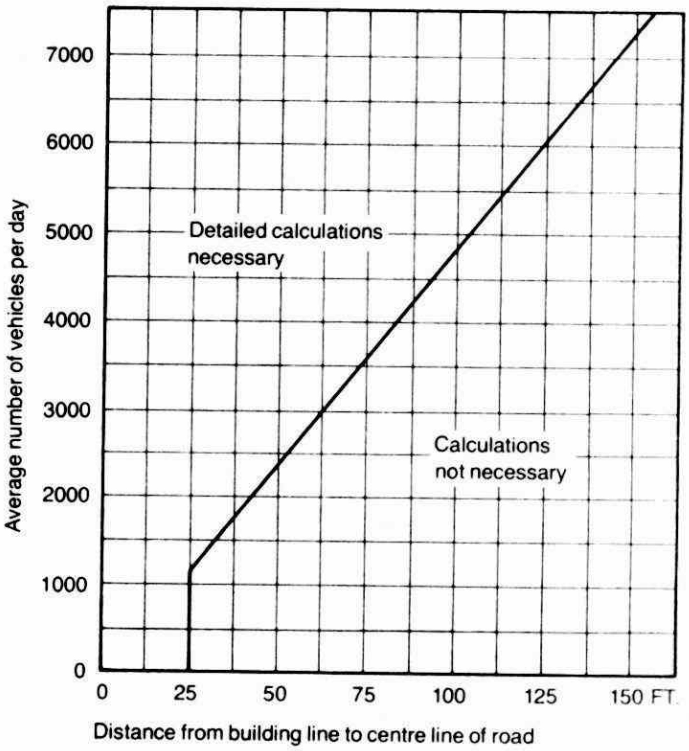
Therefore, it is not practical to use street classifications to establish the suitability for residential development of land adjacent to roads.

Need for Detailed Calculations

Even taking account of the problems and difficulties previously mentioned, it is possible to build housing near roads and railways and achieve reasonable interior noise levels provided proper measures are taken to ensure that the sound insulation is adequate.

For roads where the speed limit is 30 miles per hour or less and truck traffic is negligible (i.e. restricted to normal residential delivery), it is possible to determine whether the site is acceptable without further reference to the detailed sections of this document. Figure 2 is used for this purpose.

Fig. 2 — Need for detailed calculations



NOTE: Speed 30 mph or less
Truck traffic negligible

Section D — Classification of Areas Adjacent to Roads and Railways

Introduction
Statistical analyses of sociological surveys indicate that residents judge their living conditions in four distinct ways: convenience, attractiveness, intrusion of objectionable features such as noise, and ease of movement into and out of the neighbourhood.

People's reaction to noise may therefore be tempered by these other considerations.

Therefore, residential areas adjacent to roads and railways cannot be classified strictly according to people's reactions except in statistical terms.

Identification of Areas
In order to apply the available noise abatement information to the assessment of noise exposure at a site, the Corporation has adopted the categories listed below.

Normal construction in new residential buildings complying with "Residential Standards" should provide an acceptable indoor environment up to an outdoor noise level of 55 dB. Above this level there is an ever increasing likelihood that normal construction will be unable to provide adequate sound insulation.

Based on an analysis of available information, residential development with adequate sound insulation could be allowed up to a noise level of 75 dB. Above this, the annoyance caused by road and rail traffic so seriously affects the environment that residential development will not be acceptable for financing under the National Housing Act.

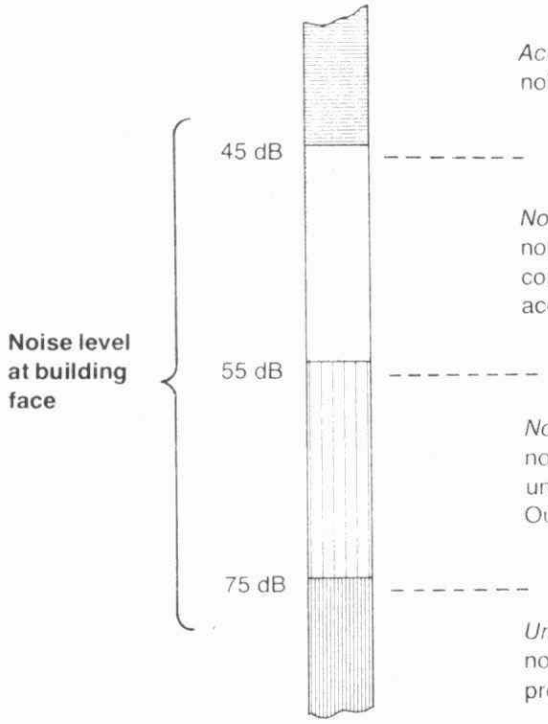
The Corporation will apply the following policy in relation to these categories:

a. in the upper zone, where the noise level exceeds 75 dB, housing shall be denied financing under the National Housing Act

b. in the intermediate zone, between 55 dB and 75 dB, housing shall be denied financing under the National Housing Act unless adequate sound insulation is provided

c. in the lower zone, where the noise level is below 55 dB, housing construction meeting "Residential Standards" provide adequate sound insulation and financing under the National Housing Act will be available.

Under its lending policy the Corporation will take into consideration the cost of adopting measures to reduce noise to the extent these measures will affect the property value depreciation that would otherwise occur.



Acceptable —
noise exposure both indoors and outdoors is unobtrusive.

Normally acceptable —
noise exposure may cause some concern but construction complying with "Residential Standards" should provide acceptable indoor conditions.

Normally unacceptable —
noise exposure is significantly more severe. Indoor conditions unacceptable unless adequate sound insulation is provided. Outdoor recreational space may have to be sheltered.

Unacceptable —
noise exposure so severe that sound insulation costs would be prohibitive and outdoor environment would be excessively noisy

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